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Sustainability Criteria for Contingency Bases

H. Garth Anderson, Annette L. Stumpf, Giselle Rodriguez, Samuel L. Hunter, and Kurt Kinnevan

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Abstract

Contingency base supply lines represent an ongoing vulnerability in U.S. contingency operations. Base camp materiel, energy, and water requirements must be met using risky ground convoys or, alternately, expensive air transport. The problem is aggravated by a lack of base camp planning and design guidelines, which negatively affect operational efficiency and logistical sustainability. U.S. design and construction communities have developed criteria to improve the sustainability of standard facilities and infrastructure, such as Leadership in Energy and Environmental Design (LEED) and the Sustainable Sites Initiative. The direct applicability of such criteria to military contingency operations is limited, however, because of unique military requirements and the scarcity of U.S. standard construction materials and equipment.

This study examined various design and construction sustainability programs and identified concepts, guidelines, and practices relevant to military contingency infrastructure construction. The report collects and adapts design and construction criteria that can feasibly be applied by engineers, planners, and base operators to establish and sustain contingency bases. Application of these guidelines could significantly decrease the logistical footprint of the contingency base by reducing the consumption of construction materials, energy, and water.

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Preface

This study was conducted for the Army Environmental Policy Institute (AEPI) under Project 370769, “Sustainable Criteria for Expeditionary Sites”; Military Interdepartmental Purchase Request MIPR10096178, dated 20 September 2011. The technical monitor was Steven Hearne, Senior Fellow, AEPI.

The work was performed by the Environmental Processes Branch (CN-E) of the Installations Division (CN), US Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Deborah Curtin was Chief, CEERD-CN-E; Michelle Hanson was Chief, CEERD-CN; Kurt Kinnevan, CEERD-CV-T was the Technical Director for Adaptive and Resilient Installations; and William D. Goran was Director of the Center for the Advancement of Sustainability Innovations (CASI). The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Ilker Adiguzel.

COL Jeffrey R. Eckstein was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.

1 Introduction

1.1 Background

Recent US contingency operations have experienced vulnerability of contingency base * logistical supply lines. The large materiel, energy, and water footprint of U.S. facilities must be resupplied via risky ground convoys or expensive airlift. This problem is exacerbated by inadequate planning and design of these bases and their varying levels of efficiency in operations, making them difficult to sustain. Most planning is reactive and performed ad hoc in response to dynamic mission requirements, unknown base camp end states, and ever changing theater policies and guidance. Additionally, design and construction standards are significantly different from those found in the Continental United States (CONUS) and can vary significantly among Combatant Commands (CCMD). Base camp planners do not have access to relevant and appropriate design criteria to assist them in making decisions that could improve total contingency base sustainability. For purposes of this report, *sustainability* is defined as planning and implementing practices that promote energy security, reduce reliance on fossil fuels, minimize the use of hazardous materials, conserve water resources, and reduce waste streams. (Source: Draft DoD Instruction 4715,ZZ, Subject: Environmental Policy for Contingency Locations Outside the United States.)

1.2 Objective

The purpose of this report is to provide military planners, engineers and base operators a set of sustainability criteria that can be applied across the life cycle of a base camp in order to reduce its logistical footprint, thereby reducing the vulnerability of its supply lines. Many of these criteria have the added benefit of improving the quality of life of base camp inhabitants and reducing the negative impact on host nation communities. This report provides a set of criteria derived from sustainability rating systems from the planning, design, and construction communities that are intended to improve neighborhoods, infrastructure, facilities, and military installations. These criteria are not intended to be prescriptive, but rather a collec-

* DoD Directive 3000.10 has adopted the term “contingency base” to describe all military contingency operation facilities. The terms forward operating base (FOB), base camp, and contingency base are used interchangeably throughout this document.

tion of concepts, ideas and practices that planners and engineers can apply to the life cycle of the base camp as mission, environment, and resources allow. By assisting the base camp staff in identifying and applying relevant sustainability measures, overall resource requirements—including power, water, construction materials, and solid and liquid waste generation —will be reduced over the life cycle of the camp.

1.3 Approach

1.3.1 Evaluation of rating systems

The research team reviewed applicable U.S. sustainability rating systems, including the U.S. Green Building Council (USGBC) Leadership in Environment, Engineering, and Design (LEED) systems for Neighborhood Development (LEED-ND), LEED for New Construction and Major renovations (LEED-NC), the Sustainable Site Initiative, Envision, and the new Unified Facilities Criteria (UFC) Master Planning Guide for Army Installations. Also included in the literature review were theater guidance documents, base camp doctrine, and international references on base camp environmental management.

First, the research team identified current sustainability rating systems to select those which might be suitable for use in contingency operations. Next, the selected rating systems were analyzed to determine the relevance and applicability of concepts and specific criteria to contingency operations.

Each credit or criteria was evaluated for its applicability to contingency operations, considering both base camp size and life cycle phase.

Relevant criteria were sorted and grouped by major themes and assigned to each of the five phases of a base camp life cycle: planning, design, construction, operations and maintenance, transfer and closure[*]. Relevant credits were then organized by phase and contingency base function or component.

This report assembles relevant criteria into a reference guide that planners and designers can use during specific base camp phases. Where feasible,

[*] Base camp phases from ATP 37-1-10, Base Camps.

specific reference material or links are provided to assist the designer with detailed information.

1.3.2 Criteria identification

After selecting the relevant sustainability-rating tools, the next step was to develop an analysis matrix to perform a detailed and systematic analysis of sustainability criteria in the context of base camp life cycle and characteristics. The key considerations were:

- Life-cycle phase
    - Site Selection and Planning
    - Master Planning
    - Design
    - Operations and maintenance (O&M)
    - Closure and turnover
- Size (from ATP 3-37.10, Base Camps)
    - extra small (population 50 – 299)
    - small (population 300 – 1,999)
    - medium (population (2,000 – 5,999)
    - large (population 6,000 or greater)
    - all
- Duration (from ATP 3-37.10)
    - Expeditionary (6 months or less)
    - Temporary (up to 2 years)
    - Semi-permanent (up to 10 years)
    - Enduring (more than 10 years)

Analysis criteria are flexible enough to allow expected changes in contingency base mission, size, and duration. While these changes are directed by the mission commander, proposed sustainability criteria are not prescriptive, allowing base camp staffs to apply where appropriate. Each tool and its sustainability criteria were systematically evaluated for their applicability and limits using current contingency base doctrinal publications (e.g., ATP 3-37.10) and theater guidance documents available such as CENTCOM Sand Book. Evaluated criteria have been rated for suitability and include short narratives describing their relevance according to the established base camp criteria. Analysis also included an overall assessment of the entire tool for its suitability in theater.

Figure 1 shows an extract of the analysis matrix. The complete matrix is reproduced in Appendix A.

Figure 1. Extract of the analysis matrix.

	A	B	C	D	E	F	G	H
1								
2	**LEED 2009 for New Construction and Major Renovations**					**Phase**	**Base Camp Size**	**Comments**
3		**Sustainable Sites**						
4	Prereq 1	Construction Activity Pollution Prevention		yes		Construction	All	primary concen dust abatement, and erosion control
5	Credit 1	Site Selection		limited		Planning	All	consider those criteria during the EBS
6	Credit 2	Development Density and Community Connectivity		no		Planning		really hard to use
7	Credit 3	Brownfield Redevelopment		no		Planning		EBS policy is to avoid contaminated sites
8	Credit 4.1	Alternative Transportation—Public Transportation Access		some		Planning	Medium, Large	locate common use facilities for easy public transit access if available
9	Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms		some		Planning, Design, Construction	Medium, Large	consider bike racks near common use facilities and LSA
10	Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles		no				
11	Credit 4.4	Alternative Transportation—Parking Capacity		some		Planning, Construction	Medium, Large	establish vehicle-free zones in high density areas. A few exceptions for commanders and emergency vehicles.
12	Credit 5.1	Site Development—Protect or Restore Habitat		some		Planning, Design, Construction	All	Be careful of any special habitat,think about what to protect.
13	Credit 5.2	Site Development—Maximize Open Space		limited		Planning, Design	All	Maximizing open space also provides flexibility for future expansion. Want to plan common use open space.
14	Credit 6.1	Stormwater Design—Quantity Control		some		Planning, Design, Construction	All	Select a well drained site. Consider permeable pavements and a good drainage system. Consider capture and reuse of rainwater.
15	Credit 6.2	Stormwater Design—Quality Control		some		Planning, Design, Construction	All	Don't want to silt up water ways.
16	Credit 7.1	Heat Island Effect—Non-roof		yes		Planning, Design, Construction	All	Concept of providing shade structures and keep existing trees for human comfort. Gravel pavement counts for this credit.
17	Credit 7.2	Heat Island Effect—Roof		yes		Planning, Design, Construction	All	Good idea for hot climates to reduce cooling load.
18	Credit 8	Light Pollution Reduction		yes		Planning, Design, Construction	All	Good idea for a different reason - design for light discipline.
19		**Water Efficiency**						
20	Prereq 1	Water Use Reduction—20% Reduction or more		yes		Planning, Design, Construction	All	Reduce water use as much as possible. Not the same baseline. Educate the people.
21	Credit 1	Water Efficient Landscaping		yes		Planning, Design, Construction,	All	We don't water landscaping. Consider rainwater if needed for food or special plants. Prefer grey water for dust control for roads.
22	Credit 2	Innovative Wastewater Technologies		yes		Planning, Design, Construction,	All	Cascading water use, save potable water for essential uses.
23	Credit 3	Water Use Reduction					All	Consider water production and distribution as a separate facility.
24		**Energy and Atmosphere**						
25	Prereq 1	Fundamental Commissioning of Building Energy Systems		yes		Design, Construction, O&M	Medium, Large	Ensure system performs per design and contract specifications. Put it in the contract!
26	Prereq 2	Minimum Energy Performance		yes		Design, Construction, O&M	All	Specify minimum energy performance in contract.
27	Prereq 3	Fundamental Refrigerant Management		yes		[illegible]	[illegible]	Most commercially available systems don't have [illegible]

1.3.3 Prioritization

The next step was to identify the most important criteria for use by the base camp team. Because there are no sustainability criteria that are universally accepted across all construction domains and military departments, each researcher independently identified the highest-priority sustainability criteria related to his or her technical discipline. These were collected in a matrix of draft criteria recommendations that also identify the appropriate phases, sizes, and durations of base camps to which the criteria would apply. This matrix is presented in Appendix B.

The final step was to produce a matrix of prototype criteria intended to provide base planners, designers, and operators' specific guidelines or recommendations to increase the sustainability or reduced logistical footprint of contingency bases. These criteria are contained in the next chapter. They were reviewed by stakeholders and subject matter experts from throughout DoD including Geographical Combatant Commands (CENTCOM, AFRICOM etc), Air Force REDHORSE (theater master planners), USACE (AFCS, TAD, etc), USAR Facility Engineer commanders, U.S. Army Engineer School, and USMA.

1.4 Scope

This analysis is directly relevant to military planners conducting analysis for future operations by providing sustainability principles for the selection of potential base camp locations. The analysis also applies to units and individuals currently engaged in contingency operations worldwide.

It generally applies to all Army elements that may be assigned responsibility for base camp planning, design, or management in a contingency operation. Other services can also apply recommended criteria to service specific contingency facilities

2 Proposed Sustainable Base Camp Criteria

2.1 Site selection and planning

2.1.1 Site selection

Above all else, the site selected for a contingency base must meet mission requirements. The selected site can have a profound effect on the resources required to support the contingency base and missions that operate from that location. During this process, there are a number of steps the planner can take to potentially reduce the logistical footprint of the camp, making it more sustainable.

2.1.2 Information gathering

The planner should use all available geo-spatial tools, information databases, and conduct onsite data gathering when feasible. Site information will drive a large number of sustainability decisions during the site selection process. (Note: Much of this information can come from the USACE District/Area Office supporting that location or area. The Army Geospatial Center is also a good source of data.)

Mapping data. This can show critical assets such as proximity to population centers, transportation networks (road, rail, air, and ship), water supplies, and construction or energy resources. The topography, geology, and potential seismic activity can greatly influence how easily a contingency base can be resupplied. USGS or NGA may have useful overseas information. Older mapping data may provide useful information on previous land uses which could indicate areas of environmental concern.

Climate data. Knowledge of the local and regional climate allows the planner to select a site that uses the weather to its maximum advantage. Details such as prevailing winds, seasonal variations, likelihood of extreme weather events and precipitation patterns are an important consideration. In Arctic or sub-Arctic regions planners must consider implications of permafrost or the depth of the freeze line as well as snow roads. Climate data is available from UFC 3-400-02 Design Engineering Weather Data and from the Air Force Climatic Control Center at:
http://www.afccc.af.mil

Available infrastructure. Depending on the intended function of the base, the adaptation and use of existing infrastructure is generally preferable to building new facilities. Planners must also consider how existing infrastructure could restrict the use of a specific location and how they anticipate restoring it to its original state. Locations without any physical remains can also be of importance to local groups. Prior research may or may not provide this kind of information. Consult the State Department or USAID.

Local Knowledge. Depending on the permissiveness of the environment, engagement with local leaders, the community, and business entities can provide extremely valuable information on local concerns, key contacts, available resources, methods and processes used locally, and size and skill of the labor pool, while gaining the trust of the community. Consult State and USAID.

Socio Cultural. Sites that are of significant cultural or natural importance or are vital to the community should be avoided if at all possible. The local population can help the planner identify important cultural sites or economic activities that could be impacted by the presence of a base camp. Their intimate knowledge of the area can provide data not readily apparent to an outside observer.

Onsite reconnaissance. This is often the best source of site data, depending on how current it is. Sources include intelligence reports and the Environmental Baseline Survey.

2.1.3 Sustainability measures

Based on collection and analysis of site data, the planner can now implement a number of specific sustainability measures into the site selection process.

Proximity to water supplies. The availability of water sources, both groundwater and surface water, near the contingency base greatly decreases dependence on resupply convoys. On-base wells are the preferred source, eliminating both resupply and decreasing the source vulnerability although there is an increased cost initial cost for well drilling and installation. Close attention must be paid to the effects that a base's water use will have on local water supplies and the aquifer as contamination or depletion of this water source might occur. If locating a base in a friendly nation, local municipal water supply may be feasible. The availability of water may change over time, particularly if a contingency base becomes a fixed base.

Water quality of source. If the base will use an adjacent or onsite water source, its quality should be thoroughly tested. The overall quality of the water can dictate the treatment technology required. Low quality water that is contaminated or brackish will likely require the use of highly effective but inefficient systems such as reverse osmosis that are energy intensive. High quality water (as determined by the Public Health Command), relatively free of pathogens and contaminants (herbicides, pesticides, chemicals) may allow the use of more standard or traditional water treatment techniques that are much less energy intensive. If drilling on-site water supply wells, if the first layer of the aquifer is of low quality, consider drilling deeper for higher quality water as drilling costs can be offset by lower treatment costs. Meters are needed to obtain quantitative information on water use.

Disposal of wastewater. Waste water should be reused as much as possible. If any water cannot be reused, the waste water must be properly disposed as required by the SOFA or OEBGD. Meters are needed to collect quantitative data on waste water generation.

Wetland and water body conservation areas. Even though the military does not recognize conservation requirements during contingency operations, conservation areas should be avoided if possible. Avoid disturbing habitats, wetlands, water bodies and neighbors who care about them. It is best to avoid the possibility of incurring liability for wetland restoration at the end of the mission. Wetland areas should also be avoided as they can increase the number of disease vectors, especially mosquitoes.

Habitat and endangered species. Base camp locations should avoid areas that are habitat to threatened or endangered plant or animal species. The presence of these species can limit access or flexibility in the use of specific areas.

Health vectors. Sites should also be located away from areas that may harbor disease carrying vectors, such as insects and rodents. These areas may include stagnant water bodies or local waste disposal areas.

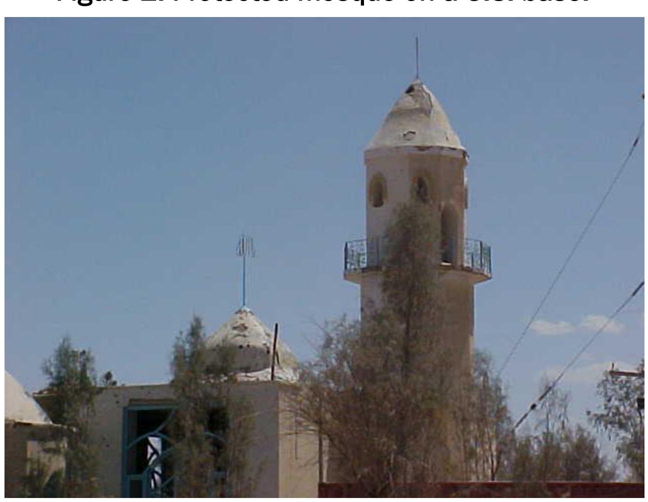
Solid waste disposal. All efforts need to be made not to generate material that will need to be disposed of in a landfill. Materials should be reused, repurposed, recycled as much as possible prior to sending it to a landfill.

Renewable energy considerations. Climate data will help determine if the use of renewable energy sources such as solar and wind are feasible at a specific location. Availability of space and soil stratigraphy could make ground source heat pump or geothermal feasible.

Use of existing facilities and infrastructure. Generally, military forces attempt to maximize the reuse of existing infrastructure such as airfields, roads, utilities, adaptable buildings, and utility metering systems. This reduces the amount of construction materials that must be transported to the site. Reuse infrastructure only if it meets mission requirements. (UFC 1-201-02 DRAFT, “Assessment of Existing facilities for use in Military Operations,” is being developed by the Tri-Service group.)

Protection and preservation of cultural or historic infrastructure. The planner should carefully consider the affect that features of historic or cultural significance have on the site. Structures that have no adaptive military reuse should be placed off-limits for military use. If avoidance of cultural features is not possible due to mission requirements, then base leadership may have to provide for controlled local access to features inside the base boundary such as cemeteries or religious monuments. If a culturally important facility is used for military operations (Figure 2), one must consider how to preserve and restore the character of the feature before turnover.

Figure 2. Protected mosque on a U.S. base.



Host nation environmental laws. In some cases, local and national environmental laws may preclude the use of specific locations. A thorough understanding of the applicability of these laws and engagement with local authorities can prevent unintended environmental damages – both physical and legal. U.S. policy is to abide by host nation environmental laws.

Road network and supply lines. An extensive road network can increase the availability of resources to a contingency base. It can also reduce the vulnerability to supply convoys as they are not restricted to a single route. Pay attention to minimizing the disruption to local traffic and commerce.

Proximity to local population. Depending on the security environment, it may be advantageous to locate near population centers. This increases the availability of local construction materials, supplies and labor.

Availability and capacity of a local power supply. By connecting to the local power supply, units could potentially reduce significant fossil fuel demand for onsite power generation. This option, however, requires planners and engineers to ensure voltages and frequencies are compatible, enough capacity is available, reliability is proven, and method of payment for services is secured. These additional resources should ensure the power consumption is managed correctly.

Local power supply is also a potential security problem. An assessment of reliability and the consequences of power interruption is needed; this represents a vulnerability that must be carefully assessed.

Availability of local resources. The availability of construction materials such as gravel, cement, compressed earth block, lumber, and construction equipment may make a location attractive for a base camp (Figure 3). Locally available resources reduce the number of supply convoys and the distance driven. Also, constructing facilities from local or regional materials may provide a building that is better suited for the climate and more culturally appropriate for turnover to the local community at the end of the mission. Planners should also consider the availability of skilled local labor and construction equipment resources.

Figure 3. Local construction materials and methods in Afghanistan.

2.2 Master planning

2.2.1 Integrated site planning

Good master planning uses a multidisciplinary team to ensure all mission requirements are met while minimizing the amount of external resources required for sustainment. The planner must understand all the requirements of the mission and operational units as well as the constraints of resources, space, contract support, and legal issues. The base camp should be approached as a complex interrelated series of systems. The master planning process generally conforms to the Joint Facility Use Board (JFUB) procedures. This planning team should include:

- Representatives from units operating in and from the base
- BASOPS staff or Mayor Cell
- Public Works
- Logistics
- Real estate
- Environmental staff
- Preventive medicine or public health
- Support contractor Logistics Civil Augmentation Program (LOGCAP)
- Legal
- Resource management (finance).

Engage community and local authorities. Depending on the permissiveness of the environment, base planners should involve the local community and leadership in some elements of planning. Involvement of the host nation and community helps the planner identify locally available resources such as construction materials and skilled labor, critical equipment, culturally significant sites, cultural dynamics, and learn how to best do business in the region. If the local community can't be directly engaged, decisions should be made that anticipate their expected requirements where possible. The planner can also implement measures in the base that minimize disruption to local daily life and business, making the base camp less intrusive and more accepted by the community. Planners should seek staff assistance from professional, trained personnel in areas such as anthropology, archeology, and sociology when possible.

Functional layout. Contingency bases should be laid out to maximize mission effectiveness allowing proximity to similar or related functions in order to minimize the requirement for the use of vehicles within the fence line. At the same time, layout must incorporate best practices in force protection, e.g., facility spacing to limit damage to multiple buildings from a single incoming rocket or mortar round. Primary zones within a base camp include training areas, operations, billeting, base camp services, medical, administrative, dining, physical fitness, MWR, light industrial, heavy industrial, AT/FP setbacks and airfields/helipads. Heavy support, industrial areas, waste water disposal, and solid waste disposal should be located away from life support areas, where possible. See Figure 4 for an example plan layout. Base layout should account for the wind direction and natural topography (surface water flow). Ensure seasonal variations are accounted for, such as areas vulnerable to runoff from snowmelt or the rainy season. Figure 6 shows the topography of a FOB site, and Figure 6 includes drainage management. Figure 7 shows a base camp layout using master planning principles.

Figure 4. Example base camp master plan layout.

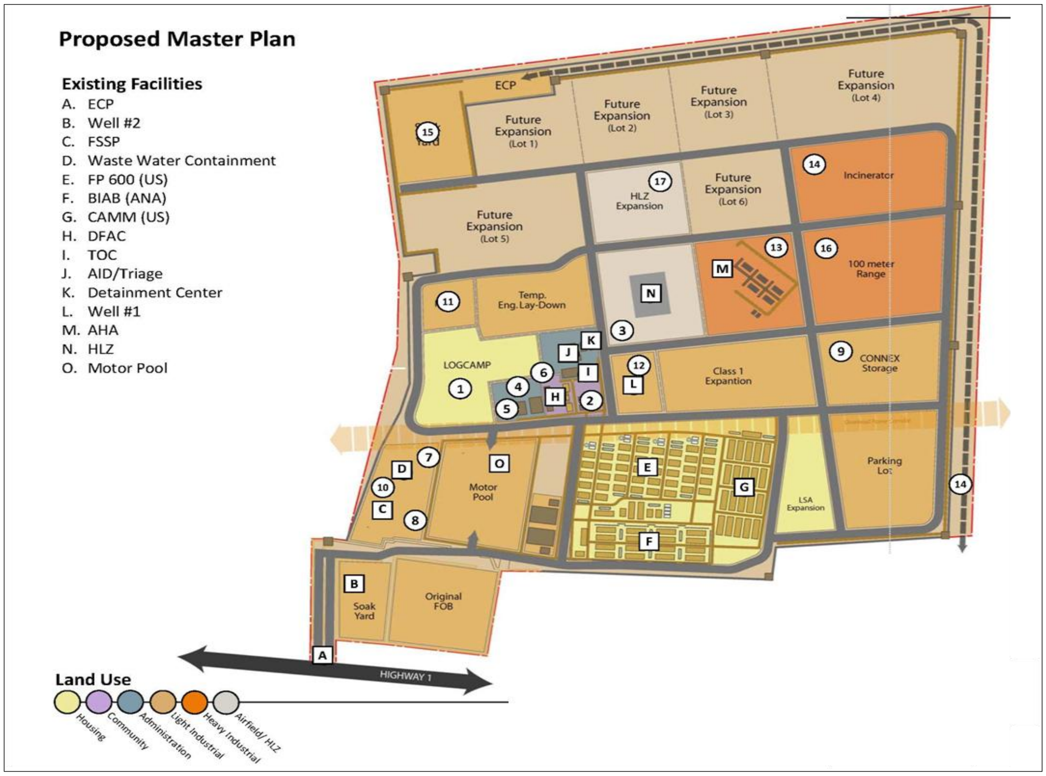


Figure 5. Topography analysis of forward operating base site.

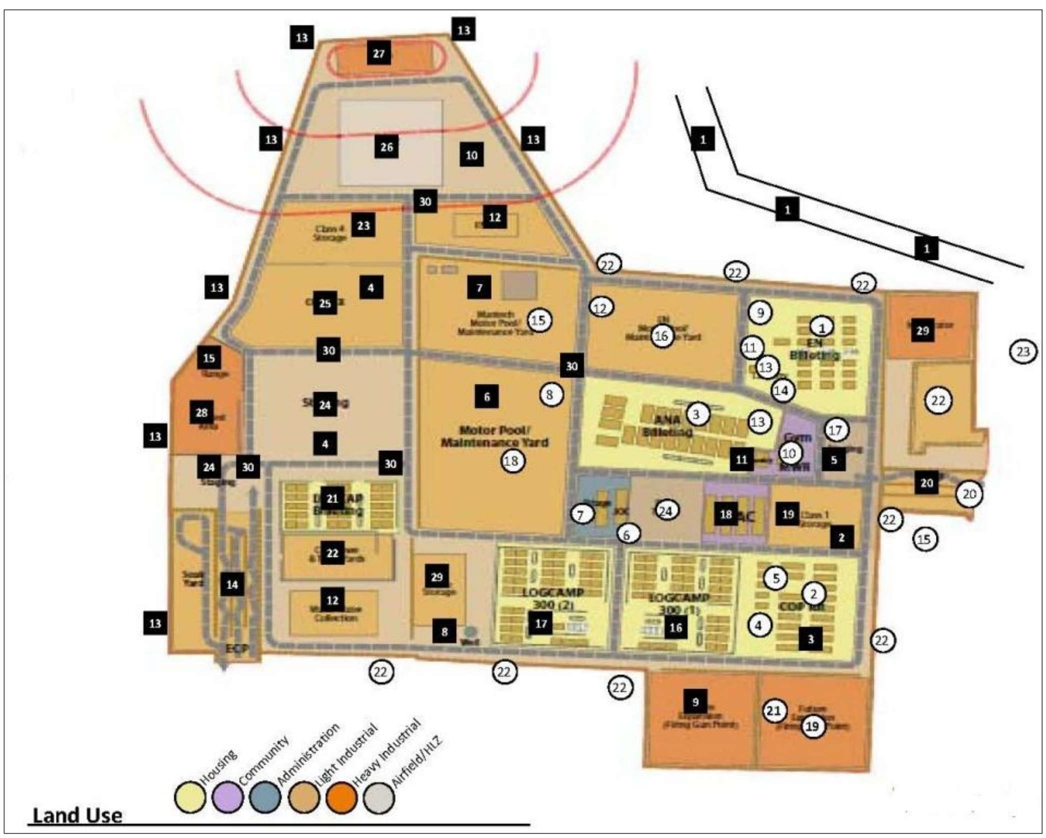


Figure 6. Topography analysis showing drainage and stormwater management.

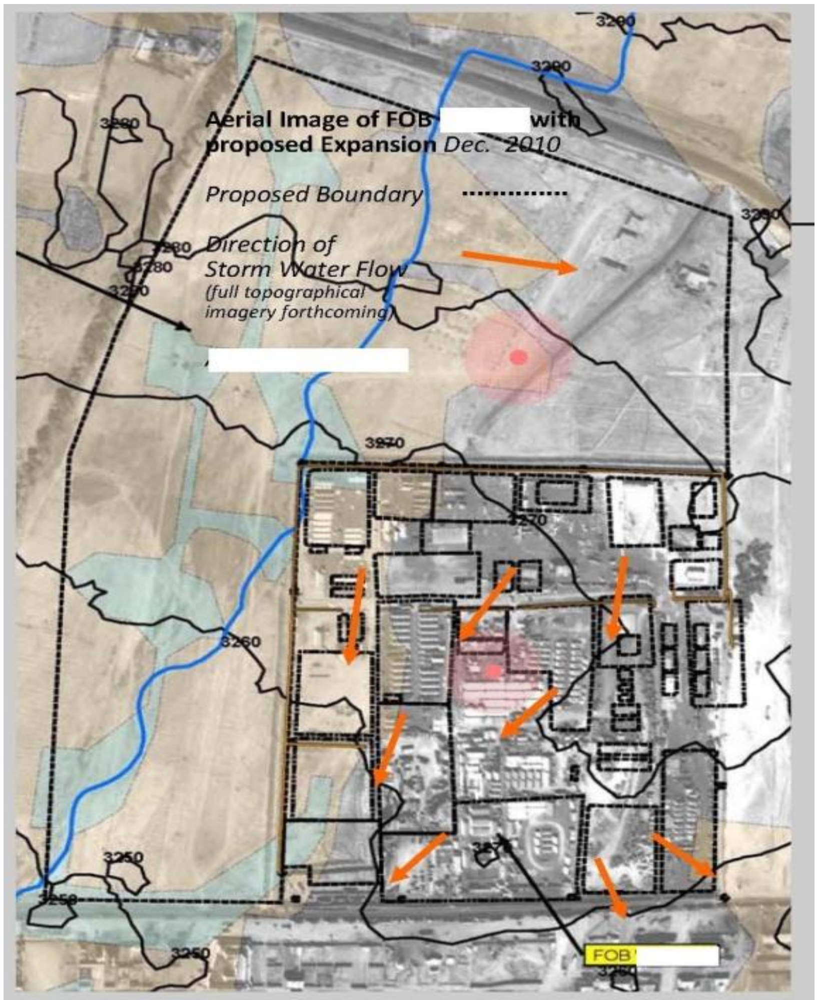


Figure 7. Base camp layout showing evidence of master planning principles.

Compact development. Plan carefully to accommodate similar functions in the same area to make development compact. For example, locating all base camp services functions (e.g., PX, MWR, gym) in one location minimizes the need for access roads, utility lines, and support vehicle parking.

Proximity. Locate facilities as close as possible to the users. For example, locating the DFAC or recreation facilities close to life support areas allows personnel to walk rather than drive to high use areas. Community service functions should also be located close to billeting areas.

Linkage and transportation networks. Safe and efficient transportation links within the base reduce the need for non-tactical vehicles by providing safe pedestrian and bicycle paths as well as public transportation. Requirement for vehicle roads is reduced through compact development and functional proximity as discussed above. Sustainability of a base can be dramatically increased through the reduction in numbers of non-tactical vehicles, or vehicles that perform administrative and convenience transportation within the camp.

Optimum site accessibility, safety, and way-finding. Master plan and site designs should include safe pedestrian paths between essential living, community services, and work facilities. Heavy truck traffic should be kept from these areas through proper zoning and by establishing separate entry control points and routes for large vehicles.

Complete streets. Construction and maintenance of major roadways is a significant commitment of resources. To reduce the resource requirement, these routes should accommodate multiple functions to include vehicle traffic, pedestrians, bicycles, and utilities. The master plan layout for major roadways should include vehicle lanes, a walking/biking path on at least one side, and wide utility corridors and storm drainage on one or both sides of the roadway. A sample street design is shown in Figure 8 and a completed design example is shown in Figure 9.

Figure 8. Sample FOB street design.

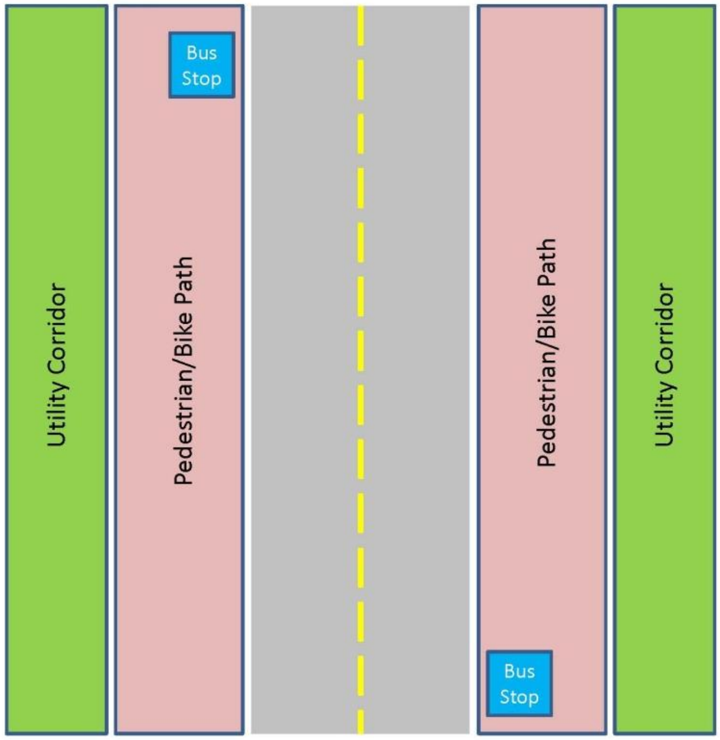
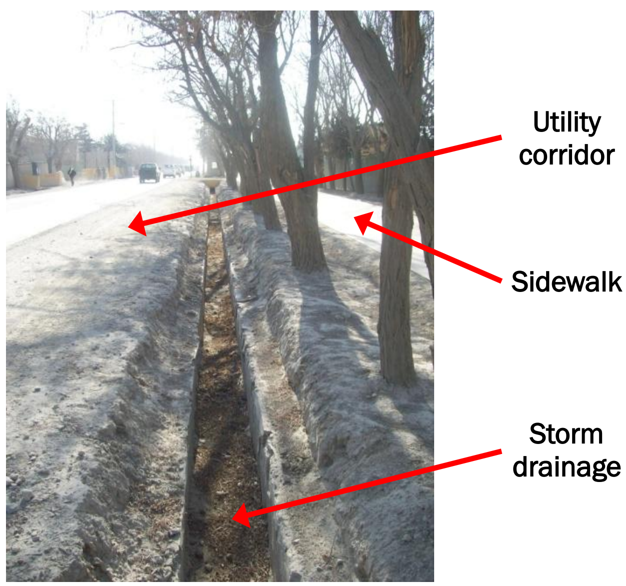


Figure 9. Complete street example at Bagram Air Field.



Public transportation. The master plan for medium to large bases should include designated routes with pick up points for some form of public transportation. These routes generally connect facilities that may be beyond walking distance from life support areas (LSAs) such as airfields and motor pools.

Reduced parking footprint. Parking in LSAs should be limited to command vehicles and a limited number of support vehicles. All other vehicles should be parked in motor pools and other work areas such as command facilities and logistical support yards. Establishing good functional layouts and pedestrian routes reduces the need for vehicular access to LSAs. Accommodate bicycle parking in LSAs and community service areas where feasible.

Use of existing facilities and infrastructure. The master plan should maximize the use of existing infrastructure that meets military mission requirements if existing infrastructure represents a more efficient and effective means over new contingency construction. The use of existing roads, airfields, buildings, and utility networks can greatly reduce the logistical requirement for base construction. Existing infrastructure can also include trees and other hardscape features. Trees can provide shade for energy reduction and can enhance personnel quality of life. Infrastructure, whether used directly or not, must be maintained throughout the life of the base camp so that it can be turned back over to the host nation in the same or better condition. Note: many existing structures may be structurally unsound or could contain hazardous materials such as asbestos that may prevent their reuse. Complete inspections are required to address any potential hazards.

Base cluster shared functions. If a contingency base is adjacent to other bases or part of a base cluster, many functions can be shared among U.S. and allied forces. For example, one base in the cluster might operate a large solid waste disposal facility that supports all, increasing efficiency through economy of scale and needing only one operating crew. Other functions might include maintenance, wastewater treatment, hazardous waste storage and processing, and warehousing.

2.2.2 Utility networks

Efficient utility networks begin with proper layout of functions to minimize the distance power, water, and wastewater must be conveyed. Networks must also take advantage of roadway utility corridors to minimize disturbance of other base camp functional areas and reduce the likelihood of cut lines during facility construction.

Plan for long-term monitoring and maintenance. Plan utility networks with expansion, and operations and maintenance considerations in mind.

Ease of maintenance reduces the logistical burden for system operation throughout its life cycle. LOGCAP* service contractors can provide valuable advice during the planning process. Lines should be accessible, well marked, and protected to facilitate maintenance and no disruption to critical base functions. Multiple utility lines should be consolidated into single excavations or utility corridors, making construction and maintenance more efficient. Meter and monitor systems and utility networks to diagnose facility performance and reduce energy and water consumption.

Utility infrastructure energy efficiency. Utility networks should minimize the distance between the source and the user to reduce electrical line losses and the cumulative effect of water leaks on supply lines.

Potable water. If piped water distribution networks are used, consider using elevated storage tanks to eliminate the need for power consuming line booster pumps (Figure 10). If a piped network is not feasible, requiring the use of truck distribution, plan for adequate storage, typically in large water bladders, as close as possible to the point of use. This minimizes the number of points requiring resupply. Plan for a three to five day supply for storage which also provides firefighting water.

Wastewater. Sewage treatment systems should be located down gradient from latrines and showers to allow the use of gravity flow sewer lines. If graywater reuse, recycling, or water cascading is anticipated, build the separation infrastructure into the wastewater conveyance system from the start. Integrate treatment of waste or “blue water” from portable latrines into the plan. This form of wastewater can present challenges because it tends to be more concentrated and have more solid material. Consider ways to reuse blackwater. If blackwater is hauled away, consider how to ensure that it is properly disposed of.

* The Logistics Civil Augmentation Program (LOGCAP) is a program administered by the US Army to provide contingency support to augment the Army force structure.

Figure 10. Elevated tank at water supply point.

Power. Some locations requiring power may be better served by energy islands rather than connection to a grid. For example, stand alone photovoltaic security lighting and energy storage on a remote corner of the base can preclude running electrical lines or operating a generator on site.

2.2.3 Power generation and storage

The master plan should provide a comprehensive approach to power generation. A vast majority of power on a contingency base is produced by some of form of diesel generator. These generators may be large prime power units concentrated into a central plant or smaller tactical or commercial spot generators. Most contingency bases will likely have a combination of these two with power occasionally supplied by a renewable source such as wind or solar.

Local power grid. If a contingency base is located in a friendly country, the host nation may offer power from its own grid. This source is the least resource intensive for the base, greatly reducing fossil fuel consumption, transportation and maintenance costs. The base planner will need to plan for backup power for critical functions such as communications, information technology, medical and command facilities. Note that using a local power grid could decrease energy security.

Host nation power characteristics. Consider adoption of host nation power characteristics from the beginning. In other words, if a country's utilization voltage is nominally 400/230 volts at a frequency of 50 hertz, that is what U.S. forces should use instead of 120/240 volts, 60 Hz. Particularly if they are connecting to the local power grid, but even when mini-grids and smart grids are utilized. At some point, these systems may be connected to local power or, at the very least, locally procured engine-generator sets and other electrical materials may be obtained more cheaply and more quickly if needed. It is also easier to enforce one electrical safety code than two codes or a variety of mixed codes.

Mini-grids. The simplest way to increase the overall efficiency of power generation is to consolidate spot generators into mini-grids. With this concept, individual generator power users are tied together into a small grid served by fewer generators. This results in fewer generators running but at higher outputs or higher efficiency. It reduces fuel consumption while providing the same amount of power. Energy security is enhanced if a mini-micro-grid distribution infrastructure distributes power across the base to better balance loads.

Smart grids. Smart grids provide the most efficient and flexible power generation of any system. A smart grid system ties together and controls multiple power generating sources, including generators, renewable energy, and power storage. This type of system is semi-automated with control systems that automatically turn generators on and off to meet current power demand. It receives inputs from multiple sources and produces clean power output.

Onsite renewable energy sources. The use of renewable power on a contingency base may be feasible if the weather conditions are suitable. Renewable power can be helpful in reducing the power requirement from diesel generators. Because renewable energy is inherently intermittent, it should not be used as a primary power source for critical functions. Renewables are best employed when power storage or smart grids are in place, and/or power islands are feasible. Geothermal resources are another possibility.

Energy storage. Renewables are feasible when a power storage system such as battery bank is available. This allows intermittent power to be stored and used later for peak use shaving or to power specific functions for a finite period of time. Power from storage can also be fed into a smart grid. Another potential energy storage method is the use of renewable power to pump water to an elevated storage tank. This water can later gravity flow into distribution lines, reducing the need for line booster pumps.

Smart grid. Renewable energy can also be fed directly into some smart grids. A modern smart grid can accept power from multiple sources, shut down specific producers when demand is lower, and produce clean power output.

Power islands. A power island is a function that is isolated from the rest of the power grid because it is remote or the nature of the function allows it. Renewable power may be feasible for certain functions that operate intermittently or for specific finite periods each day. A good example is the use of solar charged batteries for use in perimeter security lighting. An elevated water tank is another potential function.

Site. Layout and building orientation should facilitate the use of photovoltaic (PV) energy systems if implemented. Consider solar, wind, geothermal, small scale or micro hydro-electric, or biomass. These may require basic smart grid infrastructure to incorporate. Look at space requirements for solar farm or other technologies.

Energy demand reduction. Energy demand reduction measures are more easily implemented when planned and accommodated for early in the base camp development process.

Energy efficient structures. Base planners should select the best structure types based on command policies, mission requirements, construction asset and materials availability, and regional climate. Energy efficiency is more easily implemented when planned for from the beginning so structures should be designed to accommodate future efficiency measures. Serious consideration should be given to using local construction materials and methods as these are generally more suited for the regional climate.

Environmental Control Unit (ECU) management. ECUs on a base camp can account for up to 50% of power demand which means ECU management has the potential for the largest savings in energy demand of any system. The availability of specific ECU types and sizes in theater may dictate how ECUs support a specific facility. If only large capacity ECUs are available, prepare layouts to allow servicing multiple buildings with a single unit.

Power metering. Although not yet fully fielded, power metering will soon allow the base staff to make decisions on power management. By measuring demand by selected facilities, specific measures can be implemented to reduce the energy requirement. Plan for metering so appropriate infrastructure can be integrated into the power distribution grid.

Acclimatization. Proper acclimatization of personnel allows ECUs to be set at more moderate heating or cooling temperatures or make natural ventilation and cooling of buildings feasible.

Water demand reduction. Power requirements can be reduced for water treatment, distribution, heating, and wastewater management by selection of water demand-reduction measures described below.

Electric vehicles. The use of electric vehicles may be feasible if there are alternative energy sources available to recharge them. The vehicle batteries become a de-facto energy storage system. Although the use of electric vehicles may seem to be a wise choice, one should realize that if they are charged with power from generators, there is no net savings in fuel demand at the base.

2.2.4 Water management

System integration. Water management is comprehensive and must consider integration of both water and wastewater treatment systems. Stormwater management measures should also be integrated into the cycle. Planning for this integration from the start is typically more cost effective than adding systems later.

Water supply. In order to increase the security, reliability, and sustainability of a water source, on site or adjacent supplies are preferred. Truck delivery is the least desirable.

Onsite wells. Although most bases will initially be supplied by trucked-in water, base planners should move toward using water supply wells within the perimeter of the base camp to provide the most sustainable and secure source. On site supply eliminates the need to bring water in by truck. Well capacities must be understood to ensure adequate yield for the base camp and to prevent drawdown of wells in the adjacent community.

Figure 11. Well head and storage at a FOB.

Local municipal supply. If operating in a friendly country, the local municipality may be able to supply the base camp through direct hookup to water lines or trucking from a nearby water point.

Adjacent or onsite surface water. The closer the water source, the fewer resources required for transportation. Planners should be aware of the seasonal reliability of the source.

Rainwater harvesting. Rainwater and stormwater runoff can be captured in barrels, bladders, tanks, or retention ponds to provide a significant water source. If ponds are used, take measures to reduce the attraction of disease vectors. Installing gutters on buildings increases the potential volume of rainwater capture. This captured water can be used for a variety of purposes including use as raw water for the water treatment facility, dust abatement, construction, or vehicle washing.

Storage. Plan for a minimum three day supply for storage capacity. Plan for five days if feasible. Typical minimum demand at a contingency base is 25 to 30 gallons per person per day.

Shower water reuse. Small shower units with closed loop water recycling systems, approximately 12,000 gpd, are available through Army procurement sources. Examples of containerized shower units are shown in Figure 12.

Figure 12 Containerized shower unit.

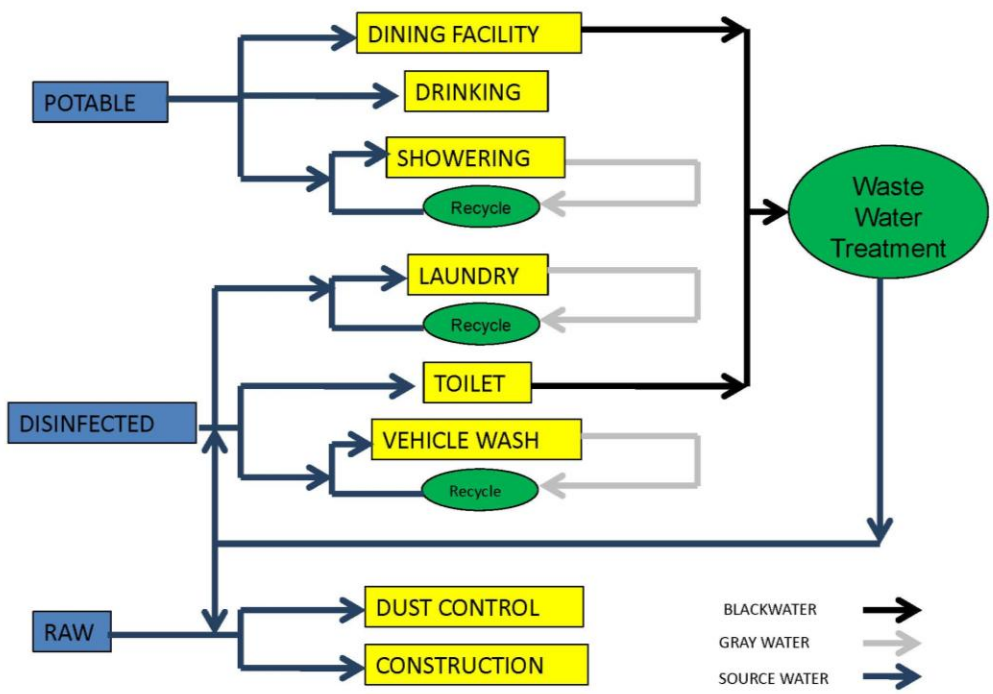
Water quality analysis. Planners should thoroughly analyze the quality of water sources before selecting a treatment method. While low quality water requires more resource intensive treatment such as reverse osmosis, higher quality water may only require minimal conventional treatment and chlorination. Figure 13 shows water samples being taken for quality analysis.

Figure 13. Medical detachment taking water-quality samples.

Multilevel treatment practices. Treating water for its intended use reduces energy requirements. Figure 14 illustrates the water reuse concept. It is recommended that water be treated and supplied for three different levels of use:

- raw—construction, dust suppression
- disinfected—toilets, laundry, vehicle wash racks
- potable—drinking, dining facility, showers.

Figure 14. Water reuse concept.



Prevent surface and groundwater contamination. When planning the base camp layout, ensure that no functions are placed where they could contaminate water sources. Maintenance, lubricating, and fueling points should be located away from water supply points and be protected with secondary containment. Ensure that these functions all have proper spill containment and response measures in place. Parking lot drainage must be controlled to prevent runoff toward water sources. Use measures such as placing drip pans under vehicles to minimize potential contamination.

Stormwater management. Designers must incorporate stormwater management into base layouts for several reasons. Good management primarily provides for proper drainage of the base. Figure 15 shows an example of poor stormwater management. Stormwater must not be drained in a way that can overwhelm the wastewater treatment plant. Finally, stormwater runoff can be captured and used as water source.

Figure 15. Example of poor stormwater management of a parking lot.

Wastewater treatment. Planners must consider a number of factors in developing an integrated approach to wastewater treatment, reuse and recycling. The master plan should reflect intended recycling and reuse at the start, ensure adequate space, adjacency, and transmission lines among processes. Factors such as available space, climate, and soil properties must be taken into account. If the use of host nation treatment facilities are considered, ensure they meet appropriate standards for treatment and disposal. U.S. Air Force guidance on contingency wastewater design is the most detailed reference available.* Another alternative is local wastewater treatment such as through a membrane bioreactor. This also would allow use of the treated water.

Semi-closed loop recycling. Systems that recycle graywater at point of use are available for vehicle wash racks, laundries, and showers. These systems can recover and recycle 50–90% of water used. Figure 16 shows a Force Provider unit.

* Engineering Technical Letter (ETL) 13-2: Design, Construction, Operations, and Maintenance of Semi-permanent Wastewater Treatment Plants at Contingency Locations, 20 May 2013.

Figure 16. Force Provider graywater recycling system.

Cascading water reuse. As water is used for its intended purpose, the resultant graywater can then be used for a function requiring lower quality water. For example, rainwater or graywater from showers can be collected and used for construction or dust suppression. If cascading is considered, ensure master plan layout and infrastructure will support it. It is important to ensure Army Preventive Medicine or Air Force Bio-Environmental personnel approve, certify, and monitor proposed water reuse strategies to ensure they meet current health standards.

Reuse treated wastewater effluent. Properly treated wastewater effluent can be recycled as source water for treatment. It can also be disinfected for use in toilets or vehicle wash racks. Ensure quality of effluent is monitored to meet preventive medicine standards.

Blackwater treatment. If extensive graywater recycling is used, it can dramatically increase the solids content of the influent. This may render standard aerobic treatment ineffective. Consider using anaerobic treatment or membrane filter systems.

2.2.5 Solid waste management

Siting. Solid waste management facilities should be located in the industrial zone of the base camp, away from cantonment areas and airfields. The facility also should be downwind from the prevailing wind direction. Ensure layout provides sufficient room for expansion, inclusion of recycling and HAZWASTE functions. Provide access for heavy vehicles that does not route them through LSAs.

System selection. During the master planning process, a number of factors should be considered when selecting a solid waste management process. Planned base camp duration, available area, climate, host nation capabilities, air quality, theater guidance, and potential waste stream composition all factor in the selection. The ultimate waste disposal method generally evolves from expedient systems such as burn pits or nonengineered landfills to more sophisticated methods as incinerators or air curtain burners. Figure 17 shows an air curtain burner. Congressional or theater guidance may limit the use of open burn pits in contingency operations. Full-capacity incinerators are large military construction projects; they are only suitable for long-term use and requires a highly trained staff to operate. Figure 18 shows an incinerator that was built in Afghanistan.

Figure 17. Air curtain burner.

Figure 18 Large-capacity incinerator in Afghanistan.

Host nation collection and disposal. Depending on the sensitivity of the environment and the permissiveness of host nation capabilities, host nation collection is the least resource-intensive and probably the least costly source for services. However, it is possible that the host nation's standards and enforcement lack the rigor to protect a sensitive environment, so a balanced evaluation is recommended.

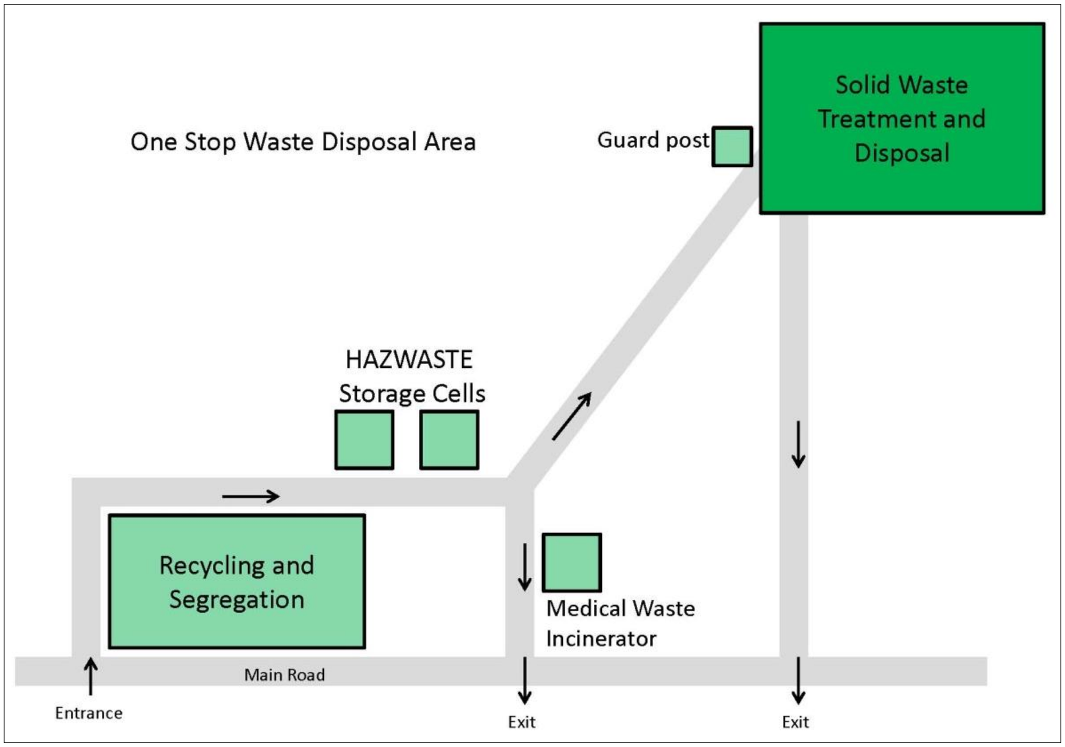
Waste stream segregation. Solid waste management begins with strategies to reduce the volume that must be treated. Other items, such as plastic bottles, hazardous materials (e.g., batteries) generally cannot be disposed of in any thermal treatment process. Base master plans should include a process and infrastructure to segregate waste streams and reuse or recycle materials. Waste segregation is most effective at the point of use or disposal. For example, provide water bottle recycling containers near DFACs and latrines (Figure 20) and battery disposal boxes at the PX(Figure 19).

Figure 19. Battery recycling box at PX.

Figure 20. Water bottle recycling container near latrine.

One-stop disposal. The master plan should include an area that facilitates all types of waste segregation, recycling, hazardous waste storage, and solid waste treatment/disposal. This type of layout makes it as easy as possible for personnel to comply with best practices for solid waste management and reducing the load on the waste treatment facility (Figure 21).

Figure 21. One stop waste disposal area.



Force protection and safety. Force protection and safety considerations (fire safety, electrical), are not generally subject to modification just for sustainability considerations. Force protection standards must be integrated into the master plan. For example, many base camps will construct a separate entry control point for service vehicles and personnel. Some functions such as waste water treatment disposal can be serviced from outside the perimeter by installation of a waste transfer line outside the wire. Other systems must adapt to meet these standards. Integrate/accommodate requirements into master planning. Figure 22, Figure 23, and Figure 24 show examples of force protection at a U.S. base camp.

Figure 22. Example of force protection at a base camp entrance.

Figure 23. Force protection around a DFAC.

Figure 24. Force protection walls and bunker for recreation field.

2.3 Design

2.3.1 General design considerations

Design for mission flexibility. Detailed site development, design requirements and construction of facilities has long term implications on the sustainability, energy and water efficiency, transportation efficiency, walkability and livability of base camps. It is important to think about public spaces, building adjacencies and transportation networks (both for walking and delivery/service vehicles) when locating structures within the functional zones established during master planning.

Keep delivery traffic separate from pedestrians. Separate functional areas requiring frequent vehicle access (e.g., DFAC, industrial, PX, refuse collection points) from billeting areas. Some functions (DFAC, PX) require both pedestrian access and vehicular delivery access (Figure 25).

Figure 25. Walkable public space in front of PX and education center (vehicular access is behind buildings).

Determine Appropriate Design and Construction Standards. Compare local construction standards to the UFC (Uniform Facility Criteria) and Base Camp Contingency Construction Standards to see whether local practices provide adequate life safety, structural integrity, and meet plumbing and electrical codes. Local construction materials and methods can reduce construction costs and make it easier to obtain local skilled labor. Buildings built using local materials and methods may be more desirable to the local population when the requirement for a contingency base has ended. If the local electrical standard is different than U.S. standards, consider using surface mounted conduit so wiring can be changed as needed.

Contingency construction requirements. Many of the geographical combatant commands produce theater-specific construction guidance and standards. For example, USCENTCOM Regulation 415-1, "The Sand Book," lists building types and allowable square footage for various base camp sizes. USEUCOM publishes the "REDBOOK" and U.S. Forces Korea uses the "TIGER Book".

Consider reuse possibilities. Both existing infrastructure and facilities could be reused or adapted to meet current mission requirements. Design new facilities and infrastructure so it could be reused or adapted by the military or local populations. Structures that can be used for multiple purposes are more flexible if mission requirements change Figure 26).

Figure 26. Standard-footprint buildings using local materials and methods, which can be modified inside for any purpose.

Plan for sustainable site maintenance. Consider ways to recycle or compost organic matter generated in dining facilities or during construction, site operations, and maintenance. Select energy-efficient fixtures for outdoor lighting. Consider using renewable energy (solar or wind) for isolated security lighting requirements. Select native plants that require minimal maintenance.

Plan for long-term monitoring and maintenance. Build maintenance into LOGCAP contracts and other O&M processes. Consider appropriate O&M for the lifespan of the component and base camp. Meter and monitor facilities to diagnose facility performance and to reduce energy and water consumption.

Promote sustainability awareness and education. Sustainability is both a planning and leadership responsibility, requiring constant vigilance by leaders to ensure the policies and programs are being implemented. Make it easy for soldiers and civilians to help meet sustainable goals. Provide awareness campaigns and tie sustainability practices to force protection payoff. Challenge soldiers, contractors, and civilians to suggest innovative ideas for saving money, conserving water and energy, recycling, and other environmental/sustainability practices. Reducing the environmental footprint of everyone at the base camp reduces the risk and expense of transporting water, fuel and other supplies to the camp.

Provide for stakeholder involvement. Think of the community as people inside the base camp fence. For that community, use the base camp planning board process and the Joint Facilities Use Board (JFUB). If the project has the potential to affect the host nation community, then you should engage the local nation leadership.

2.3.2 Site design

Prevent surface and groundwater contamination. This applies to everyone in the base camp including soldiers, civilians, and contractors. Consider stormwater flow and potential for leaks or spills during design to avoid surface and groundwater contamination. Refer to Army Standard Operating Procedures and policies that apply for spill response, secondary containment, hazardous response, etc.

Improve infrastructure integration. Apply good master planning principles to achieve higher performance. For instance, design the main roads with adequate room for adjacent stormwater ditches, safe sidewalks/pedestrian paths, and utility corridors (Figure 27). The sidewalks/pedestrian paths could be over underground utility corridors.

Figure 27. Well designed main road with adequate utility corridors and safe space for pedestrians.

Compact development. Design facilities to accommodate similar functions in the same area to make development compact and more walkable. Consider multistory (if possible) or mixed-use structures to reduce construction costs. Encourage daily physical activity by locating housing within walking distance to work, dining, and recreational facilities. Separate functional areas requiring frequent vehicle access (e.g., DFAC, industrial, PX, refuse collection points, etc) from billeting areas. Carefully design facilities (DFAC, PX) that require both pedestrian and vehicular delivery access.

Access to civic and public spaces. Locate life support areas as close as possible to common use areas (PX, Post Office, Finance Office, Learning Center). Provide a variety of open spaces close to work and housing to encourage daily walking, socialization and connection to the outdoors (Figure 28).

Figure 28. Well designed public space adjacent to billeting and DFAC.

Walkable streets. Design major roads with adjacent sidewalks to provide safe walking paths for base camp occupants. Pay special attention to roads that connect LSA (life support areas) to common use areas. Consider safe fitness (walking/running/bicycling) trails within the base camp perimeter.

Reduced parking footprint. Discourage parking in life-support areas. Consolidate parking in vehicle motor pools, and permit mission only parking at command and control facilities. Provide bicycle parking where appropriate. Provide fire and emergency access in billeting areas while limiting permanent parking so people walk instead of driving unnecessarily.

Use an integrated site development process. Use a multi-disciplinary team during master planning, site development, design and construction. Team members should include engineers, preventive health, tenant unit representatives, power generation personnel, contracting, financial, and legal. Consideration of multiple viewpoints throughout the base camp development process can help prevent costly environmental problems or planning mistakes and create an adaptable community that meets mission requirements.

Access to recreation facilities. Locate life support areas as close as possible to recreation areas (DFAC, gym, ball fields). Encourage physical activity and socialization by providing safe and convenient walking/running/ cycling paths between housing and recreation facilities (Figure 29).

Figure 29. Recreation facilities, gym, PX, and social gathering spots co-located.

Improve site accessibility, safety, and wayfinding. Good master planning and design is the key to providing easy, safe access to facilities for the camp. Planners need to consider soldier pedestrian paths to essential living and recreational and work facilities. Separate heavy truck traffic from life support areas. Protect and secure cultural and environmentally sensitive areas. Provide visual clues or signs to help orient new people to the community and protect them from hazards or sensitive areas.

Improve community mobility and access. Select sites that avoid traditional local community routes or access roads. Design entry control points and truck holding areas to minimize traffic congestion. Separate heavy equipment and delivery traffic from residential, local, or pedestrian traffic zones.

Promote and support healthy living. If possible, provide a dedicated jogging track with smooth surfaces (possibly along roadways). Accommodate a recommended fitness center. Improve the food education system by providing caloric counting information. Provide suggested minimum values for daily water allocations (for hydration and personal use) and HVAC usage to ensure comfortable conditions for resting and recovering after working outside in extreme conditions. Display a matrix showing time of exposure to temperature minimums if necessary to identify HVAC requirements.

2.3.3 Water efficiency and wastewater management

Water conservation. Safe potable water is essential to life. Location and climate will affect availability and cost of generating potable water. All personnel—military, civilian, and contractors—must understand the requirement to personally use water as efficiently as possible to meet mission requirements. Consider potable water reduction strategies for all uses and contracts (see Sholze et al. 2009). The use of bulk water is far more efficient than using bottled water. Approximately 20% of bottled water is wasted while the bottle itself creates a waste stream that is difficult to manage.

Building water efficiency. High efficiency fixtures such as low-flow or push button timed showerheads, waterless urinals, composting or chemical toilets, dual flush toilets and horizontal-axis washing machines can dramatically reduce building water consumption. (Chemical toilets may prevent use of technologies that reuse water.) It is also important to specify and install water saving fixtures for commercial kitchens, medical facilities, showers and other water intensive facilities, and in all contracted operations. Consider providing water stations for refilling personal water bottles with potable water to reduce disposable bottles. EPA's WaterSense program labels certified water-saving products. Similar products may be available in other countries: http://www.epa.gov/watersense/

Commercial kitchens. The Food Service Technology Center website offers suggestions for saving water (and energy) in commercial kitchens: http://www.fishnick.com/

Water treatment technologies and standards. Consider cascading water use to save potable water for essential uses. Use appropriate water treatment standards and technologies for different uses (potable water for drinking, cooking, and bathing; rainwater, brackish, or graywater for dust suppression; appropriate water for concrete – see Paragraph 4.2.4 for more detail). Look at life-cycle costs of water treatment systems. For example, the Reverse Osmosis Water Purification Unit (ROWPU) is effective but has high O&M costs (TM 10-4610-215-10).

Portable latrines and "blue water" treatment and disposal must also be considered since it is related to the wastewater stream and processes. This form of wastewater can present challenges to contingency base wastewater treatment plants as it tends to be more concentrated and have more solid material.

Metering. Consider adding meters to water supply and treatment systems, high water using facilities and also within the water supply network to enable monitoring for leaks or other water losses.

Site water efficiency. The military doesn't typically add landscaping or irrigation unless it is necessary to establish groundcover to prevent erosion. There may be situations where cultural resources such as a special rose garden (Figure 30) or important trees have been watered by local populations. Use rainwater, surface water, or graywater for landscape watering instead of potable water. Caution is needed when watering food gardens to avoid contamination.

Figure 30. Kandahar Rose Garden, a culturally significant landscaping feature requiring preservation.

Innovative wastewater technologies. Commercially available systems can be used for onsite remediation and beneficial reuse of wastewater. One example is Worrell Water Technologies' *Living Machine* system which uses living plants and beneficial microorganisms to turn wastewater into clean water. This technology is being tested at installations in an DoD technology demonstration project (http://www.serdp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/ER-201020 http://www.livingmachines.com/About-Living-Machine.aspx).

Wastewater management. Use systems that recycle/reuse graywater such as: dishwasher pre-rinse, showers, laundry, vehicle wash racks. Design for cascading water reuse, e.g., graywater for construction or dust abatement. Consider flushing toilets with rainwater or graywater from sinks or showers. Investigate packaged systems for most efficient potable water use and recycling (see section 2.2.4).

2.3.4 Power generation and energy efficiency

Power management. See section 2.2.3 for a detailed discussion.

Fuel availability. Consider availability and type of fuel as a critical planning element. Defense logistic networks are geared to provide JP4. Use of diesel for power generation should be evaluated with caution.

Onsite renewable energy sources. Key to reducing fossil fuel use. Reduce fossil fuel use as much as possible and maximize power generation from renewable resources. For facilities, plan space to set up smart grids (Figure 31) and energy storage or components that can operate independently off renewable sources like stand alone PV security lighting. Site layout and building orientation should facilitate the use of PV if implemented. Consider solar, wind, geothermal, small scale or micro hydro-electric, or biomass. It may require basic smart grid infrastructure or battery storage to incorporate these technologies into the electrical grid. Look at space requirements and opportunities for solar farm or other technologies.

Figure 31. Generators retrofitted with smart-grid controls.

Waste-to-energy (WTE) systems. At the time of this report, there were no deployable WTE systems. However, promising research and development projects have identified potential WTE systems that use solid waste, used petroleum products, or waste water treatment by-products to produce usable thermal or chemical energy.

Infrastructure energy efficiency. Strive to make basic infrastructure more energy efficient. Consider elevated water tanks vs. pump driven pressure lines. Minimize electrical line runs to reduce losses. Use stand alone PV powered security lighting. Provide cascading water reuse infrastructure.

Reduce energy consumption. Start from the beginning and focus on demand reduction measures. Include energy efficiency requirements in contracts and make sure everyone is aware that energy and water conservation is a command emphasis. Install power metering systems to track energy consumption (Brown et al. 2012).

Purchase energy efficient products. Obtain the most energy efficient equipment, fixtures, and replacement parts as possible. Standardize purchases and contracting requirements with minimum efficiencies but allow for improved energy efficiency as technologies and components change.

Building specifications. It isn't easy to rapidly build an energy-efficient temporary structure without access to all the building materials available in the United States and other developed countries. But every effort to improve the energy and water efficiency of new and existing buildings will reduce the environmental footprint of the base camp. Start with the contingency base camp construction standards and take advantage of any local practices and innovative ideas or materials that are available. If the local population builds masonry structures because not much wood is available, then consider adapting that approach. Take advantage of lessons learned and establish regional energy efficiency requirements, building designs and specifications.

Heating, ventilation, and air conditioning (HVAC). Environmental Control Units (ECU) are used to provide fresh air, heating and air conditioning as needed for human comfort. Building temperatures should allow personnel to work and sleep comfortably while helping everyone acclimate to the new climate and temperature. Try to specify and purchase ECUs that are appropriately sized for the facility thermal loads to minimize energy use. If the only available ECUs are oversized, then consider sharing one ECU between several buildings (Figure 32). Make sure the system and controls are commissioned and work properly. Consider natural ventilation when possible (Figure 33).

Figure 32. ECU serving multiple buildings.

Figure 33. Structure with windows to allow natural ventilation.

District heating and cooling. Use of a central or district system to provide heating and cooling capability to multiple facilities at the same time can increase efficiency and reduce costs. Also, waste heat from a central process could be used to heat water for showers and latrines. Consider capturing condensate to supplement water supply. Consider how an integrated system approach could be designed to increase efficiency, save energy and reduce costs.

2.3.5 Materials and resources

Existing infrastructure reuse. Reuse buildings if they meet mission requirements (Figure 34 and Figure 35). If a structure is culturally significant preserve the character of the building (See Section 4.1.2 for further discussion.)

Figure 34. U.S. forces reused this flight tower at Tallil after capturing the airfield in 2003.

Figure 35. A Kuwaiti National Guard Barracks reused to house U.S. soldiers in 2003.

Maintain onsite structures, hardscape, and landscape amenities. Maximize use of existing infrastructure and maintain as appropriate.

Historic and cultural resource preservation. Preserve, protect and respect unique historical places and culturally significant structures and features. Conduct a thorough Environmental Baseline Survey (EBS) to identify historic and cultural resources. Coordinate with local authorities and higher staff. Avoid if possible, but if used for military operations, then preserve and restore before turnover. Planning access for local people to certain sites may be needed.

Local/regional materials and techniques. Promote the use of local materials and techniques to reduce transportation, increase local skilled labor pool, and create culturally and environmentally preferable facilities. Use not only regional materials but also regional construction techniques (Figure 36). Modify practices as needed for life, health and safety.

Figure 36. Using local construction materials and labor.

Materials reuse. Maximize use of onsite and salvaged materials.

Recycled content materials. Maximize use of existing infrastructure, recycled construction materials and recycled content in materials. Concentrate on buying "big ticket" items (such as concrete and steel) with high recycled content levels if possible. Reclaim concrete for road gravel. For example, structural steel has a very high recycled content, anywhere from 50–85%. Rebar is 99% recycled. Steel has a default recycled content value of 25% or higher. Other materials with a high recycled content include anything metal, gypsum, or composite woods (particle board, OSB).

2.3.6 Indoor environmental quality

Indoor air quality (IAQ). Design and commission HVAC systems to provide adequate fresh air for building occupants. Keep smoking areas away from fresh air intakes. Use high efficiency air filtration media to remove dust and pollutants from indoor air and inspect/replace frequently due to expected increase in dust, sand, and/or pollution in the air.

Construction IAQ. Avoid contamination of HVAC and other system components during construction. Protect materials before and during construction to prevent moisture damage or mold growth on absorptive building materials such as wood or drywall.

Low-emitting materials. If possible, specify and purchase low-emitting materials such as adhesives and sealants, paints and coatings, flooring systems, composite wood and agrifiber products. Products that contain toxic chemicals or outgas can cause health hazards to the building occupants. Avoid problems e.g., FEMA trailers used after Hurricane Katrina, where hazardous levels of formaldehyde outgassed from the particle board and caused serious health problems to trailer occupants. Formaldehyde and other chemicals can cause burning eyes, congestion, sore throat, coughing, breathing difficulties, frequent sinus infections or rashes, and difficulties concentrating.

Indoor chemical and pollutant source control. Design to minimize and control the entry of pollutants into buildings and later cross-contamination of regularly occupied areas. Capture dirt and contaminants at building entries using permanent entryway systems or frequently cleaned walk-off mats. Sufficiently exhaust each space where hazardous gases or chemicals may be present or used (e.g., maintenance facilities, garages, housekeeping and laundry areas, copying and printing rooms) to create negative pressure with respect to adjacent spaces when the doors to the room are closed.

Controllability of lighting and thermal comfort systems. If possible, supply individual task lighting in open office areas, and allow temperature adjustment in individual rooms.

Daylight and views. If possible design structures to allow natural daylighting in regularly occupied spaces.

2.3.7 Solid waste management

Divert waste from landfills. It is very important to minimize the volume of waste entering a landfill in order to extend its useful life. Establish recycling and reuse stations. Collect paper, glass, cardboard, metals, wood, and other materials that can be recycled on the base or in the host nation. Avoid disposing hazardous materials in a landfill. Use one-stop waste disposal, where all classes of waste are disposed in one area. Compost food waste. Establish scrap wood pile, scrap metal pile, ammunition amnesty spots, plastics, and styrofoam (Figure 37). Segregate waste streams for maximum reuse and recycling (Figure 38).

Figure 37. Scrap metal collection.

Figure 38. Separate HAZMAT facility in 2003.

Storage and collection of recyclables. Design recycling areas into facilities. Provide recycling collection near point of disposal to encourage compliance (e.g., plastic bottles outside of DFAC) (Figure 39). Inspect waste loads to minimize recyclable disposal.

Figure 39. Plastic bottle recycling bins placed near DFAC exit.

Construction waste management. Design components for deconstruction, disassembly and reuse or recycling. Utilize standard-size materials and assemble using bolts, screws, and other types of connectors that promote easy disassembly. Divert construction and demolition materials from disposal. Nonhazardous construction demolition materials should be reused for current projects or stockpiled for future projects. Repurpose if feasible. Minimize construction debris that must be disposed of in a burn pit or landfills. Think about what happens after base camp occupants move out. Avoid problems such as foamed tents and buildings that can't be reused by local populations. Good examples include the use of exterior conduit so wiring can be converted to host nation code.

Source Reduction. Strive to procure materiel that minimizes waste generation. A high percentage of solid waste at a contingency base comes from packaging and shipping materials. By using bulk water treatment rather than bottled water eliminates one plastic waste stream. The use of washable utensils and plates in a DFAC can drastically reduce the volume of solid waste generated by the facility.

2.4 Construction

2.4.1 Preconstruction activities

Reviews. Construction management (CM) personnel should participate in design reviews to ensure they understand the sustainability features and requirements of the project. They should also ensure that the project is easily constructed, operated, and maintained. The CM team should review the contract plans and specifications with the contractor to provide clear guidance and understanding of the sustainability requirements. CM must also review any construction submittals, evaluate materials, and provide concurrence before work begins.

2.4.2 Materials and resources

Existing infrastructure. When the mission calls for the use of existing infrastructure, the CM team can take measures during construction and remodeling to maximize sustainability by minimizing destructive or intrusive methods. Electric and data cabling should be routed through surface mounted conduit or raceways rather than routing through and behind walls. If the requirement is for new non-load bearing interior walls, they should be of minimal construction and easily removed or relocated if requirements change. Ductwork from exterior environmental control units can be routed through existing windows rather than punching new holes in the building envelope.

2.4.3 Cultural resources

Impact to adjacent features. Extra precautions must be taken to avoid or minimize the impact to nearby or adjacent cultural or historical features. If possible, local authorities should be consulted before starting construction. If a cultural resource is particularly sensitive (e.g., a mosque or cemetery), it may be preferable to have local workers perform the protection and preservation tasks. Protect nearby features from vehicular traffic, site runoff, and personnel access. If cultural resources are encountered during construction, stop immediately and notify the chain of command. If work is being performed in an area likely to encounter cultural resources, it may be necessary to have an archeologist on site.

Adaptive reuse. The military mission may require the adaptive use of historical and culturally significant structures and features (Figure 40). If possible, local authorities should be consulted before altering the facility. Construction methods should be low impact and easy to undo upon transfer. Major structural modifications or measures that significantly alter the cultural significance should be avoided.

Figure 40. Gulf Region Division reused this art museum as an office facility from 2003 to 2009. Source Dovan, Tim LTC, "Wisconsin Guard has key role in Baghdad's future," http://dma.wi.gov/dma/news/2009News/09134.asp.

Figure 41. Performing QA inspection of local materials and labor.

Local materials and techniques. Use local materials and techniques to reduce transportation, increase local skilled labor pool, and create culturally and environmentally preferable facilities (Figure 41). Many of these construction methods can be adapted to build standard footprint military facilities. For example, an equivalent of a standard wood framed structure can be built from masonry or adobe. Be cautious of using locally procured roofing and sealing products as they may not be regulated for health and safety.

Pre-engineered buildings. The use of pre-engineered fabricated metal buildings can often reduce transportation costs and construction time Many pre-engineered building manufactures have offices worldwide. These structures are typically manufactured to tighter tolerances resulting in a more airtight and energy efficient facility. Arch-Span pre-engineered buildings can be quick and simple to construct. Additionally, pre-engineered buildings do not require as much skilled labor for their construction, increasing the availability of suitably skilled local labor force Figure 42 shows an example of a prefabricated metal building.

Figure 42. Prefabricated metal buildings in Afghanistan.

Materials reuse and cross leveling. Maximize use of onsite and salvaged materials. Recycled materials such as reclaimed concrete can be used for road gravel. Soil cut-and-fill operations from multiple project sites can be balanced across the base. Class IV construction materials should be centrally managed on the base (Figure 43). Larger materials orders from multiple projects are more efficiently hauled and stored. Leftover materials from one project can be used on another.

Figure 43. Centrally managed Class IV yard.

2.4.4 Construction management

Quality control and quality assurance. Poorly constructed facilities can be both energy inefficient and dangerous to occupants. A good quality control and quality assurance process ensures that a facility meets the plans and specifications, uses the proper materials, and accommodates power, plumbing, and HVAC components. The result is a more energy-efficient structure.

The quality control (QC) process is the responsibility of the builder to ensure construction is done according to the plans, specifications, and permit requirements. The CM team should review and approve the contractor's QC plan prior to starting work. Having the contractor perform QC during construction will prevent costly repairs after project completion.

Quality assurance (QA) is the responsibility of the base personnel to ensure the contractor performs required QC and construction quality standards outlined in the plans and specifications are met. QA personnel perform construction oversight and often function as the Contracting Officer's Representative (COR), ensuring the construction meets the contract requirements. The QA Representative or COR should be experienced construction personnel.

Scheduling. Proper construction scheduling minimizes waste of time and resources. Equipment on standby or waiting in line still consumes fuel. Prolonged disruptions to other camp activities by utility outages and road blockages increases resource consumption as personnel employ other means to continue operations.

2.4.5 Pollution prevention

Stormwater management. Minimize the effects to the existing site as much as possible to avoid a need to restore the site when the base camp is closed. Construction can alter stormwater flow. Capture runoff for use in concrete mixing or dust control. Good stormwater management also reduces construction effects on nearby facilities. Ensure that proper erosion control features such as silt fencing and check dams are in place.

Site disturbance. Minimize the area adjacent to the project that must be disturbed. The site should be controlled with designated parking and entry and exit points. Mature trees should be protected to the maximum extent to prevent erosion and to provide shade to buildings and personnel.

Dust control. Uncontrolled fugitive dust from construction activities can be a health and safety hazard. Use captured runoff or recycled graywater for dust abatement.

Prevent surface and groundwater contamination. Avoid surface and groundwater contamination. Ensure spill control equipment is on site. Use secondary containment for temporary storage of fuels and other hazardous materials. Establish a landfarming site to stockpile and remediate POL-contaminated soil.

2.4.6 Construction waste management

Divert construction and demolition materials from disposal. Reuse non-hazardous construction demolition materials for current or stockpile for future projects. Additionally, proper estimation of bills of material reduces the amount of leftover or scrap material. Don't procure extra material that will then need to be disposed of.

Promote recycling. Include at the construction site collection facilities to segregate waste for recycling, reuse, and disposal. Make leftover or scrap materials available to soldiers for personal projects such as shelves and small furniture. The local community often can use leftover construction materials.

Construct for transfer or disassembly. If it is known that the facility will be deconstructed at the end of the mission, use construction techniques that promote the disassembly and reuse of building components. Wherever possible, use standard size materials and assemble using bolt and screw connections that can be disassembled. Use of some materials such as spray-on foam insulation may prevent reuse or recycling of wall panels and piping. Using surface mounted electrical conduit facilitates easy conversion to local code if the facility is transferred (Figure 44).

Figure 44. Use of surface-mounted electrical conduit.

Commissioning. Ensure systems perform per design and contract specifications before acceptance and final payment to the contractor. This final inspection and performance testing will prevent or minimize missing or incorrectly installed equipment, occupant complaints and callbacks, indoor air quality issues, thermal comfort problems, premature equipment failure, and litigation.

2.5 Operations and maintenance (O&M)

A site maintenance plan, addressing long and short-term strategies to keep systems up to date and therefore operating in optimal conditions, should be developed and distributed to all responsible parties. However, this process should start early during design and construction phases of a project. These reports should be independently created, to ensure that future users can easily understand what is required for O&M without depending on information from any prior tenants. By creating continuity and ensuring optimal performance of systems across the site, less fuel will be needed for operation and fewer resources will have to be used for repairs. This maintenance plan should cover the following.

2.5.1 Energy systems management

The first step to develop an operations and maintenance plan that would ensure the most efficient operation of energy and water systems is to create a master list of all base equipment. This list should contain at least location of the item, serial number, condition assessment, and date of procurement. If possible, this list should include a reference of required spare parts and specifications.

Assign a team to check that all generators are operating efficiently and are serviced in a timely manner. Keep a record file and note dates of installation and all repairs performed. Report all proper preventive maintenance activities performed and work orders resulting.

This team should also monitor all HVAC equipment and regularly check for temperature and comfort levels. It is recommended to maintain an operating plan that includes at least occupancy schedule and equipment runtime schedule. Note in this plan any changes in schedules due to different seasons, days of the week and times of day and adjust lighting and temperature as needed. If available, choose energy efficient maintenance equipment and appliances.

Preventive maintenance services for all HVAC equipment are imperative for optimal operation (Figure 45). Thus, these should be scheduled regularly and all recommendations or repairs be well documented.

Figure 45. ECU maintenance inspection.

2.5.2 Water systems management and maintenance

Potable water systems. The first step to ensure a proper maintenance for water systems is to have the right equipment and well trained personnel in charge of monitoring that water quality meets the standards. Report any contaminant levels above the established limits. Monitoring equipment should be as easy to manage and read as possible, opt for colorimetric instruments. Encourage water reuse, for non-potable purposes, by keeping the infrastructure clean and accessible (Figure 46).

Figure 46. Well maintained water treatment system in Afghanistan.

Wastewater treatment systems. As with potable water systems, trained personnel and regular sampling are important. Sampling results will be the indicator of the system's performance. Samples should be taken at the influent and effluent stages of the treatment for comparison. Use portable sampling and analysis devices for continuous monitoring of quality. These devices are commercially available and provide accurate results avoiding sample transportation issues. In addition to sampling, and regardless of the treatment technology used, the treatment plant operator should keep a record of all the equipment within the treatment facility and schedule maintenance actions in a timely matter. Water equipment such as pumps and motors should be inspected frequently to avoid unexpected failures.

2.5.3 Non toxic cleaning, painting, flooring, supplies

If available, use maintenance products that are low in volatile organic compounds (VOCs) and are not harmful occupants. Opt for low or no mercury content in lamps, and low emitting materials. If these products are not accessible onsite or not available for purchase, ensure that the current products are safely stored and disposed of, personnel are trained to properly handle them, and a spill management plan exists and is used when needed.

2.5.4 Stormwater management low impact development maintenance

Ensure that stormwater systems are operating effectively by creating a schedule for inspection and removal of debris or sediments accumulated in gutters periodically to maintain the normal flow of water. Encourage the collection of stormwater for non-potable uses such as irrigation, construction and dust control.

2.5.5 Waste management

Solid waste plan. A plan is important for diverting waste from landfills to reuse. This plan should be started with a material flow and waste characterization study, that includes an estimate of how much waste is generated in the site, how much of it has potential for recycling or composting, is hazardous and requires special handling, and how much does not have any market and will just be landfilled.

Reuse of materials. Provide space and accessibility for reusable materials like wood, gravel and dirt.

Recycling. Research the surrounding local areas for recycling markets and identify the products that have real potential for recycling. This will avoid unnecessary stockpiling if a market does not exist. Once recycled products are identified, keep recycling collection points accessible and close to the point of generation. For example, keep a plastic bottle recycling station close to the DFAC and keep the recycling collection area clean and attractive. Consider offering rewards to soldiers for recycling to encourage participation. Inspect waste loads to minimize recyclable disposal (Figure 47).

Figure 47. Inspection of loads at solid waste processing facility.

Composting. After the composting system is in place, educate personnel in charge of the DFAC and commercial food establishment on how to separate the plastic and paper waste from the food waste and scrapings to be used as compost. Keep composting collection stations close to the actual trash can and as the recycling station, keep it clean and ensure proper collection to avoid odors and insects. At the actual composting site, have trained personnel in charge of keeping the system maintained and controlled. To maximize the use of the composted material make sure others are aware of the availability of the composted materials and the uses this material has. If composting is not feasible, consider allowing food waste to be used in the local agricultural market as animal feed.

Hazardous waste. Keep soldiers and civilians informed of what types of waste are hazardous or require special handling and keep collection sites accessible and close to point of generation. Operations should conform to standard rules for waste handling, collection, and disposal.

2.5.6 Environmental management plan (EMP)

The first step in the development of an efficient environmental management plan (EMP) is to designate an officer, with sufficient environmental protection knowledge, as a primary point of contact. Environmental Officer training is available through the U.S. Army Engineer School. This officer should be involved in the development of the plan and in charge of supervising its execution. The EMP must be signed by the Commander.

The 2008 Environmental Guidebook for Military Operations recommends the following elements to be included in the EMP:

Environmental roles and responsibilities. This should identify parties responsible for the incorporation of environmental considerations in support contracts, and for monitoring, evaluating and enforcing contractor's compliance.

Environmental Management Board. The main function of this board is to identify the applicable standards and available resources and to review any audits.

Applicable environmental protocols and best management practices. These protocols should be evaluated to be consistent with the duration of the deployment and the resources available. Host nation laws and regulations should be taken into consideration.

Training requirements and training deficiencies. General education, technical and awareness training should be included. Rotational forces should focus their training on the unique challenges associated with the deployment.

Reporting, recordkeeping and archiving. Good recordkeeping practices ensure continuity within rotations and facilitate base closure.

EMP evaluation and updating process. The EMP should be a living document that can be updated based upon feedback and lessons learned.

2.5.7 Self-help programs

Contingency base camps should develop a self-help program where service members can improve facilities on their own with the help of Class IV materials. Service members can improve IAQ and reduce infiltration by using materials procured at the Class IV supply office and make the improvements themselves. DPW offices can provide guidance on doing small repairs/improvements.

2.5.8 Demolition of selected unused facilities (not complete closure of base)

Planners can also recommend removing facilities no longer needed on the base camp. This could potentially reduce power, water, and energy demands.

2.6 Transfer and closure

Guidance. Contingency base transition must first comply with theater guidance such as the USFOR-A Base Transition Smartbook. Command policy will dictate decision authority levels, processes for infrastructure and property disposal, environmental standards, and final site documentation. There are three types of base disposition including closure which is the complete removal of all function. A transfer involves turning all portions of the base to local authority, and a partial transfer in which only portions of the base are transferred while other parts remain active.

Facilities to transfer. Facilities and infrastructure that can be transferred to the community should be identified early so steps can be taken to prepare for handover. Each command should have a prioritization process.

Engagement of community and local authorities. When a contingency base is designated for closure or transfer, the base personnel should immediately begin engaging local authorities. (The engagement should occur prior to and during the life of the contingency base.) The community knows best what facilities and infrastructure is suitable and what can be maintained after the base closes. Other materiel and equipment that will not return to the U.S. or be transferred to other bases should also be identified. This may include locally purchased vehicles and construction equipment, building materials, generators, pumps, and usable petroleum products.

Historical and culturally significant structures and sites. Unused but protected sites should be turned over at the earliest opportunity. Facilities that were adapted for military use should be restored to their original state unless improvements are of value and acceptable to the community (i.e., basic repairs such as roofs and windows).

Local materials and methods. Facilities that were built using indigenous techniques and materials are likely the most suitable for direct transfer. Local skilled labor will have the ability to operate and maintain this infrastructure without the need for specialized skills and equipment.

Documentation of final conditions. Conditions of all facilities and land must be thoroughly documented as they are on the day of transfer. This documentation is compared to the original conditions as shown in the initial Environmental Baseline Survey (EBS) and any subsequent updates. This documentation verifies that U.S. forces caused the least amount of impact as mission and conditions would allow.

Transfer of hazardous waste. Typically HAZWASTE must be shipped out of the country under the Basel Convention requirements. However, some waste oils and fuels may be suitable for local recycling or use as heating fuel.

Disposition of hazardous materials. Usable materials such as petroleum package products, batteries, and cleaning products may be suitable for donation to the community.

Environmental restoration. Some areas of the base may require remediation of contamination caused by U.S. military operations. Look for low-impact methods, such as landfarming for fuel contamination of soil. Landfarming is a method used to decontaminate soil through systematic cleansing or by aeration to promote microbial bioremediation. In an effort to mitigate environmental damage to former Canadian FOBs throughout Kandahar province, soil from around those bases has been shipped to a remediation plot and treated with a chemical compound to flush out heavy metals and toxins (Figure 48). Composting is a related method that is effective for various contaminants that are decomposed relatively easily through microbial activity. Areas requiring cleanup should be identified as early as possible to allow remediation methods enough time to achieve required standards.

Figure 48. Landfarming to remove toxins from contaminated soil (from Andrews, Austin, “Combat Close-out”, December 18, 2011 at http://www.disposablewords.net/?p=6060).

Disposal of demolished facilities. Facilities that are not transferred to local control may be demolished. To the maximum extent possible, usable fixtures, components and materials should be salvaged and donated to the local community. Wood debris may be suitable as a heating fuel or reused by the local population to build new structures. Steel and concrete may be recycled for use in local construction projects. Use non-potable water to control dust.

3 Conclusions and Recommendations

3.1 Conclusions

Incorporation of sustainability criteria into base camp planning, design, construction, operations and closure processes will improve the long term sustainability of Base Camps, reduce water and fuel consumption, and reduce the logistical tail associated with those essential resources.

The United States military's continued transformation to an expeditionary force coupled with an era of ever declining budgets, makes the implementation of sustainable base camp practices more important than ever. By reducing dependency on liquid logistics (fuel and water) and other materials required to build and operate contingency facilities, military forces reduce vulnerability to enemy action and while allowing limited resources to be applied to more critical missions. Development of sustainable contingency bases is not a feel good endeavor but an important shift in military priorities and culture because it enhances mission effectiveness. Sustainable basing is no longer an option, but a critical consideration in the planning and execution of military operations.

3.2 Recommendations

1. Update Army policy to apply to contingency bases. The Army Energy Goal Attainment Policy, and the Army Water Goal Attainment Policy do not apply to contingency bases as currently written, however they could be revised to serve as an ASA(IE&E) driver to reduce energy and water use, and encourage the use of a sustainability rating system or sustainability criteria for contingency bases.
2. Integrate sustainability considerations into Unified Facilities Criteria (UFC) 1-201-01, "Non-Permanent DoD Facilities in Support of Military Operations." This UFC is based on International Building Codes (IBC) and provides life, health, and safety standards for contingency construction. It is also the standard that contingency facilities must meet in order for the LOGCAP contract to assume O&M responsibilities. By including sustainability criteria into the UFC, they become enforceable standards.

3. Provide input into the USACE Contingency Master Planning course. This ensures that the dedicated contingency engineering and master planning community is familiar with these practices.
4. Develop relationship with the Installation Management Command (IMCOM) Contingency Branch to integrate these practices into policy. As IMCOM assumes responsibilities for enduring bases in theater, their adoption of sustainability practices can further promote their use in all phases of the contingency base life cycle.
5. Integrate appropriate sustainability criteria into the Army Facility Component System (AFCS). AFCS is the central repository for all contingency construction and design data. By incorporating sustainability principles into the AFCS database, they become part of the standard facility design library.
6. Ensure sustainability criteria are considered in development of applicable DoD, Joint and Service guidance for contingency locations. Examples would be next iteration of the Sandbook or its equivalent; the proposed Contingency Location Environmental Standards (CLES) proposed in a draft DoDI to complement the Jan 13 DoDD 3000.10.
7. Sustainable solutions should be evaluated and prioritized based on benefits and these prioritized solutions should be added to UFC and AFCS criteria for implementation based on availability of resources and mission.
8. Further research could be conducted to analyze the green cultural practices described in this report and develop a cost/benefit payback ranking. This study could characterize the probable implementation success so teams could immediately incorporate the more easily implemented practices and further study ideas that are more costly to implement.
9. The team could discuss project management planning ideas such as: What is the method of implementation? Who are the likely POCs for initial coordination and follow-through implementation? Is there a timeline that can be expressed for complicated implementations?

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Appendix A: Evaluation and Selection of Suitable Sustainability Rating Tools

Selected rating tools

This section describes the sustainability rating tools identified for consideration during this project, and explains those that were evaluated in more detail. The ERDC-CERL research team screened the sustainability rating tools listed below, and selected five for further consideration. None of the sustainability rating tools evaluated is suitable as-is for immediate use by base camp developers. However, individual credits and criteria found in several sustainability rating tools could be applied to contingency base camps if the base camp developer considered the sustainability ideas along with security aspects and site location constraints. The use of appropriate sustainability criteria in the actual planning context could result in a contingency base that is more hospitable and consumes fewer resources to build and maintain.

Leadership in Energy and Environmental Design (LEED)

LEED* is an internationally recognized certification system. There are nine different rating systems that project teams can use during the project life cycle, from planning, to design, construction, and operations and maintenance. LEED is a voluntary, consensus-based program that provides third-party verification of green buildings, neighborhoods and communities. LEED takes a holistic approach to sustainability by recognizing performance in these nine key areas:

- sustainable sites
- water efficiency
- energy and atmosphere
- materials and resources
- indoor environmental quality
- locations and linkages
- awareness and education
- innovation in design
- regional priority.

* LEED is a registered trademark of the US Green Building Council, Washington, DC.

LEED has been adopted by design professionals and their customers, state and local governments, federal agencies including the Department of Defense; and has been used in projects in 120 different countries. There is a large network of design professionals and builders who are knowledgeable about LEED, many example projects, and an extensive catalog of references and training resources available. Guidance is available for each LEED prerequisite or credit to explain the intent, requirements, benefits and issues to consider, implementation, related credits, documentation guidance, and references and resources available.

Projects that fully comply with the LEED prerequisites and minimum program requirements can be registered to be “certified” by the Green Building Certification Institute (GBCI). Project teams select one of the nine rating tools, and then show evidence that they meet the technical requirements to earn credits. The more credits a project team earns, the higher the LEED certification will be – ranging from certified, to silver, gold and platinum. Project teams must follow the prescriptive requirements to earn a credit, and this level of effort is unlikely to happen during planning, design, construction and operation of a contingency base.

For this project, we selected the two most relevant LEED rating systems to analyze for use in Base Camps: LEED 2009 for Neighborhood Development and LEED 2009 for New Construction and Major Renovations.

LEED 2009 for Neighborhood Development (LEED-ND)

LEED 2009 for Neighborhood Development is specifically designed to help developers, planners, architects, engineers, and others plan and develop a neighborhood from the beginning, while considering existing amenities and infrastructure. LEED-ND explains how to select and develop a site into an environmentally responsible neighborhood that is a healthy place where people can travel without relying solely on automobiles. Appropriate LEED-ND principles have been incorporated into the newly revised UFC 2-100-01 Installation Master Planning. LEED-ND was considered in detail for this project because the credit intent, requirements and strategies described in the rating tool could be helpful for base camp planners.

It would be very challenging to apply LEED-ND in its entirety to base camps because the intent of LEED-ND is to weave the new neighborhood closely into the fabric of the existing neighborhoods, and base camps are typically isolated due to security concerns. But many LEED-ND credits and strategies appear useful if they are considered “within the fence” during development of a Base Camp. Other LEED-ND credits appear useful when taken into consideration when interacting with the communities surrounding the base. For more information, see https://new.usgbc.org/leed/rating-systems/neighborhoods.

LEED 2009 for New Construction and Major Renovation (LEED-NC)

LEED-NC applies to new construction projects and major renovations, and helps project teams design and construct high performance sustainable facilities. The U.S. federal government has adopted LEED for New Construction and Major Renovations. It is very familiar to project teams who have designed or built LEED certified buildings for the federal government or private sector. LEED-NC has been required since FY2008 Military Construction (MILCON) projects built by the Army per a January 2006 policy. The Army has been quite successful in implementing LEED-NC and improving the quality of construction. Army facilities certified using LEED-NC have been reducing their energy and water consumption to meet federal and Army mandates.

It is more challenging to meet all the LEED credit technical requirements for OCONUS MILCON projects because other countries have different building codes and standards, construction practices, and materials/systems that may not meet the GBCI certification requirements. More information is at https://new.usgbc.org/leed/rating-systems/new-construction.

All construction outside of the United States is also governed by country specific Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

LEED-NC has not been required for use during contingency operations because it would be difficult to comply with LEED requirements in remote locations and it is not feasible to certify projects due to the uncertain duration of contingency bases. There are many useful ideas found in LEED-NC that can be applied directly to planning, design, and construction of facilities in contingency bases, and a wide variety of resources to answer many questions.

The Sustainable Sites Initiative

The American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, and the United States Botanic Garden worked together to create voluntary national guidelines and performance benchmarks for sustainable land design, construction and maintenance. SITES promotes sustainable land development and management practices that can apply to sites with and without buildings, including military complexes and campuses. The USGBC anticipates incorporating the SITES guidelines and performance benchmarks into future versions of LEED rating tools. SITES contains sustainable benchmarks for soils, hydrology, vegetation, human health and well-being and materials selection in order to improve and regenerate the ecosystem.

SITES has useful concepts for selecting and developing contingency sites, but it can't be applied in its entirety since it is not the intent of contingency base planners to focus on plants or landscaping for aesthetic purposes. However the SITES concept of not damaging the ecosystem during site development is something that military planners should consider because it is more difficult, expensive, and perhaps impossible to restore ecosystem services once they are lost. Natural and cultural resources are very important to the communities who live near sites where contingency bases are built, and sustainable practices can help reduce possible conflicts with local populations. For more information see http://www.sustainablesites.org/.

Envision 2.0 Sustainability Rating System

Envision 2.0 is the product of a joint collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure (ISI). Envision is a rating system that provides a holistic framework for evaluating and rating the community, environmental and economic benefits of all types and sizes of infrastructure projects. The ISI was founded by the American Society of Civil Engineers (ASCE), the American Council of Engineering Companies, and the American Public Works Association. These three organizations were driven to improve the condition of infrastructure in the United States to address many key issues related to increased environmental and sustainability performance requirements, the ASCE Report Card (2009) on infrastructure, regulatory and environmental protection programs, a need to promote economic improvement, and a lack of effective approaches that could be agreed upon as being sustainable. ISI worked with the ZOFNASS program to develop the Envision 2.0 guidelines to aid in optimizing the sustainability of an infrastructure project during the planning and preliminary design phases. It is intended to educate planners, designers, and citizens and increase public awareness, provide a means to measure sustainability in infrastructure, and facilitate the adoption of sustainable practices for infrastructure the same way that LEED did for building-scale sustainability. Envision 2.0 consists of five categories of sustained practices:

- quality of life
- leadership
- resource allocation
- natural world
- climate and risk.

Envision was assessed for use for contingency bases because infrastructure is a necessary component in the various sized bases. It contains some excellent ideas that can be adapted during the planning/design/construction of contingency bases, but their process of deciding if the project is a good idea that will benefit the community for the long term is an awkward fit for people who are tasked with developing a contingency base for military reasons. For more information, see http://www.gsd.harvard.edu/research/research_centers/zofnass/zofnassratingsystem.html or http://sustainableinfrastructure.org/index.cfm

UFC 2-100-01 Installation Master Planning (15 May 2012)

This UFC is a wholesale change from the previous version, which was based on Technical Manual TM 5-803-1, dated 13 June 1986. It is intended to incorporate current approaches to master planning, and is applicable to all military installations, with the exception of overseas contingency operations/areas. The UFC was a joint effort between the services and describes how the principles of sustainability can be used to shape decision making on future capability, infrastructure footprint and land use patterns. Appendix B contains best practices, and Appendix C describes suggested sustainable planning principles appropriate for incorporation into installation master plans. The authors of UFC 2-100-01 have done an excellent job of merging key principles found in the LEED-ND (2011 version) with the DOD master planning process. The principles are applicable at the Area Development Plan scale prior to construction, and the DOD goal is to have all ADPs perform at the Silver level. This document addresses the conflicts between security requirements on military bases with the openness and connectivity desired in the outside communities. UFC 2-100-01 is intended to help shape permanent DOD installations and infrastructure that house military and civilian personnel and their families in a community setting which is secure but not isolated from the world outside the fence. Military planners using the new UFC have an opportunity to make vast improvements in the long term sustainability of their installations.

UFC 2-100-01 was selected for review because it is the best example of how to apply sustainable planning to military installations discovered during this research project. This report identifies planning principles described in the UFC for permanent installations which could be applied to non-permanent contingency bases in more remote locations which have very different constraints. For more information visit: http://www.wbdg.org/ccb/DOD/UFC/ufc_2_100_01.pdf.

Systems and tools not applicable to contingency basing

LEED 2009 for Existing Buildings: Operations & Maintenance (LEED-EB)

This tool helps building owners and operators measure operations, improvements and maintenance, with the goal of maximizing operational efficiency while minimizing environmental effects. LEED-EB focuses on whole building cleaning and maintenance issues, recycling programs, exterior maintenance programs, and systems upgrades. Use of LEED-EB would be most beneficial if your organization wanted to make a systematic investment in improving the building systems and cleaning/maintenance practices.

That level of effort is not consistent with the shorter term view of planning and managing facilities in a contingency operation, so LEED-EB was not reviewed in detail for this project. The LEED-NC principles that apply to designing or renovating efficient buildings are suitable for contingency bases without adding any credits specific to LEED-EB. For more information visit https://new.usgbc.org/leed/rating-systems/existing-buildings.

CEEQUAL (Sustainability Assessment and Awards for Civil Engineering, Infrastructure, Landscaping & the Public Realm)

This is a sustainability assessment and awards scheme for civil engineering, including all infrastructure, landscaping, and the public realm (the space between buildings). CEEQUAL has been used in the UK, Ireland, and International projects. CEEQUAL for International Projects covers Zone 1: Europe and Northwest Africa; Zone 2: Gulf States and Middle East; and Zone 3: Rest of the World. Version 5 is the latest edition of the CEEQUAL Methodology, which transitioned from an environmental assessment and awards to a sustainably assessment and awards scheme.

Only CEEQUAL Assessors/Verifiers can access the full Assessment Manual, so our team was not able to review the detailed rating criteria for applicability for contingency bases. Without being able to fully review CEEQUAL our team could not determine its applicability to contingency bases. CEEQUAL Version 5 has the following sections:

- Project Strategy (new)
- Project Management
- People and Communities
- Land use and Landscape
- Historic Environment
- Ecology and Biodiversity
- Water Environment (fresh & marine)
- Physical Resources
- Transport.

For more information, see http://www.ceequal.com/.

IR250-1 Sustainable Design and Construction for Industrial Construction (Construction Industry Institute [CII])

This is a consortium of building owners, engineers, and construction contractors who seek to improve the cost effectiveness of the capital facility project life cycle, from pre-project planning through completion and commissioning. CII has a research program involving more than 30 leading universities, which focus on topics of interest to their members. In 2007-2008, the CII Sustainable Design and Construction in Industrial Construction Research Team (RT 250) produced several reports that defined sustainability, described government and corporate trends, corporate-level efforts, benefits and barriers, and then recommended paths forward for the industry regarding sustainability. The publication IR250-2 "Sustainable Design and Construction for Industrial Construction: A Primer" was written for the industrial sectors of manufacturing, mining, minerals and metals, pharmaceutical, petrochemical, pulp and paper, power, and utilities. The domain covered by this publication is very different than planning contingency bases so it was not reviewed in detail by the research team. For more information see https://www.construction-institute.org/source/Orders/index.cfm?task=1&PRODUCT TYPE=SALES&DESCRIPTION=&FindSpec=11%2E06&CFTOKEN=74916549&continue=1&SEARCH_TYPE=find&FindIn=4.

Zofnass Program for Sustainable Infrastructure (Harvard University's Graduate School of Design)

When the current project began, the Zofnass website offered the research team an interesting framework for sustainable infrastructure which had four major categories: Quality of Life, Resource Allocation, National World, and Climate Change. These major categories are then applied to the phases of an infrastructure project: design, construction, operations, and decommissioning. The Zofnass program has a robust research effort to improve the sustainability of infrastructure, and worked with the Institute for Sustainable Infrastructure (ISI) to implement their ideas into the current version of Envision 2.0 Sustainability Rating System. Since this program has merged into Envision 2.0 it was not included in this analysis.

Environmental Guidebook for Military Operations

This publication was developed by a multinational working group from the defense organizations of Finland, Sweden and the United States for use by deployed forces. "It is intended to serve as an environmental guidebook to help troop contributing nations with environmental management responsibilities identify relevant environmental requirements, practices, standards and preventative measures with a goal of integrating them into the planning and execution of military operations that enhances the readiness of the force and accomplishment of the overall mission. It provides overarching principles, guidelines, templates, and examples which may be used by operational planners and deployed forces to achieve the overall environmental goals and objectives with a military operation."

This is a very useful reference, but it is more useful for environmental baseline surveys before a site is developed, and for protecting the environment during operations and site closure. Table 4-1 Considerations for Environmental Protection (page 24-25) lists suggested environmental protocols for short, medium and long term operations for items such as wastewater, solid waste, hazardous waste, medical waste, hazardous materials/POL, air pollution, potable/non-potable water, noise, natural/cultural resources, pest management and spill response. Many of the concepts were covered in other sustainability rating tools which were evaluated for this project. For more information see http://www.denix.osd.mil/international/upload/Environmental-Guidebook-for-Military-Operations.pdf and http://www.denix.osd.mil/international/upload/ECOPS-guidebook-052306.pdf

Environmental Baseline Survey Handbook: Contingency Operations Overseas (December 2009)

This reference was not reviewed because it is not intended to be a sustainability rating tool. Instead it

> contains guidelines for conducting an Environmental Baseline Survey (EBS) and an Occupational and Environmental Health Site Assessment (OEHSA) prior to establishing a base camp during contingency operations. The EBS and OEHSA are assessment tools used on areas U.S. forces may occupy to identify potential health threats and environmental contamination. If military personnel understand the impact that environmental and health threats can have on mission accomplishment, and they employ this information as they plan, occupy, and close deployment sites, they will ensure fiscal and material resource responsibility, protect the Army against liability, and strengthen the relationship between the Army and the host nation. The EBS and OEHSA should be conducted prior to units occupying an area. If this is not possible, they should be done within 30 days of occupation.

It is an essential tool to help teams with prior environmental background or training conduct the EBS that would then be required to site and develop a contingency base. For more information see http://www.wood.army.mil/usaes/dei.html

Appendix B: Unabridged Analysis Matrix

LEED 2009 for New Construction and Major Renovations		Applicability	Phase	Base Camp Size	Comments
	Sustainable Sites				
Prereq 1	Construction Activity Pollution Prevention	yes	Construction	All	primary concen dust abatement, and erosion control
Credit 1	Site Selection	limited	Planning	All	consider those criteria during the EBS
Credit 2	Development Density and Community Connectivity	no	Planning		really hard to use
Credit 3	Brownfield Redevelopment	no	Planning		EBS policy is to avoid contaminated sites
Credit 4.1	Alternative Transportation—Public Transportation Access	some	Planning	Medium, Large	locate common use facilities for easy public transit access if available
Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	some	Planning, Design, Construction	Medium, Large	consider bike racks near common use facilities and LSA
Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	no			
Credit 4.4	Alternative Transportation—Parking Capacity	some	Planning, Construction	Medium, Large	establish vehicle-free zones in high density areas. A few exceptions for commanders and emergency vehicles.
Credit 5.1	Site Development—Protect or Restore Habitat	some	Planning, Design, Construction	All	Be careful of any special habitat, think about what to protect.
Credit 5.2	Site Development—Maximize Open Space	limited	Planning, Design	All	Maximizing open space also provides flexibility for future expansion. Want to plan common use open space.
Credit 6.1	Stormwater Design—Quantity Control	some	Planning, Design, Construction	All	Select a well drained site. Consider permeable pavements and a good drainage system. Consider capture and reuse of rainwater.
Credit 6.2	Stormwater Design—Quality Control	some	Planning, Design, Construction	All	Don't want to silt up water ways.
Credit 7.1	Heat Island Effect—Non-roof	yes	Planning, Design, Construction	All	Concept of providing shade structures and keep existing trees for human comfort. Gravel pavement counts for this credit.
Credit 7.2	Heat Island Effect—Roof	yes	Planning, Design, Construction	All	Good idea for hot climates to reduce cooling load.
Credit 8	Light Pollution Reduction	yes	Planning, Design, Construction	All	Good idea for a different reason - design for light discipline.
	Water Efficiency				
Prereq 1	Water Use Reduction—20% Reduction or more	yes	Planning, Design, Construction	All	Reduce water use as much as possible. Not the same baseline. Educate the people.

LEED 2009 for New Construction and Major Renovations		Applicability	Phase	Base Camp Size	Comments
Credit 1	Water Efficient Landscaping	yes	Planning, Design, Construction, O&M	All	We don't water landscaping. Consider rainwater if needed for food or special plants. Prefer grey water for dust control for roads.
Credit 2	Innovative Wastewater Technologies	yes	Planning, Design, Construction, O&M	All	Cascading water use, save potable water for essential uses.
Credit 3	Water Use Reduction			All	Consider water production and distribution as a separate facility.
	Energy and Atmosphere				
Prereq 1	Fundamental Commissioning of Building Energy Systems	yes	Design, Construction, O&M	Medium, Large	Ensure system performs per design and contract specifications. Put it in the contract!
Prereq 2	Minimum Energy Performance	yes	Design, Construction, O&M	All	Specify minimum energy performance in contract.
Prereq 3	Fundamental Refrigerant Management	yes	Design, Construction, O&M	Medium, Large	Most commercially available systems don't have CFCs.
Credit 1	Optimize Energy Performance	yes	Design, Construction, O&M	All	Ensure system performs per design and contract specifications. Put it in the contract! Consider smart grids, micro grids, emergency power, load shedding, lots of possibilities here.
Credit 2	On-Site Renewable Energy	yes	Design, Construction, O&M	All	Want renewable power for remote systems (security lighting, etc.) and as much as possible.
Credit 3	Enhanced Commissioning	no			too hard.
Credit 4	Enhanced Refrigerant Management	some	Design, Construction, O&M	Medium, Large	based solely on what is available.
Credit 5	Measurement and Verification	some	Design, Construction, O&M	All	several metering and monitoring systems are being evaluated for fielding
Credit 6	Green Power	no			we don't buy power off the grid
	Materials and Resources				
Prereq 1	Storage and Collection of Recyclables	yes	Design, O&M	All	put collections of recyclables near point of disposal
Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	yes	Planning, Design, Construction, O&M, Transfer & Closure	All	Reuse building if meets mission requirements and if culturally significant preserve the character of the building
Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	yes	Planning, Design, Construction, O&M, Transfer & Closure	All	Reuse building if meets mission requirements and if culturally significant preserve the character of the building
Credit 2	Construction Waste Management	yes	Design, Construction	All	do it, but the metrics are different.

LEED 2009 for New Construction and Major Renovations		Applicability	Phase	Base Camp Size	Comments
Credit 3	Materials Reuse	some	Design, Construction	All	do it, but the metrics are different.
Credit 4	Recycled Content	some	Design, Construction	All	do it, but the metrics are different.
Credit 5	Regional Materials	yes	Design, Construction	All	promote the use of local materials and techniques to reduce transportation, increase local skilled labor pool, and create culturally & environmentally preferable facilities.
Credit 6	Rapidly Renewable Materials	some	Design, Construction	All	do it if available, metrics different.
Credit 7	Certified Wood	no			not going there.
	Indoor Environmental Quality				
Prereq 1	Minimum Indoor Air Quality Performance	yes	Design	Medium, Large	do it, not sure about metrics, be careful of combustion sources and exhausts and solvents. Consider where the burn pit is and the wind direction.
Prereq 2	Environmental Tobacco Smoke (ETS) Control	yes		All	no smoking in the buildings or tents
Credit 1	Outdoor Air Delivery Monitoring	some	Design, Construction, O&M	Medium, Large	want desired air changes per hours. Put in contract for large facilities/MILCON?
Credit 2	Increased Ventilation	no			bonus - free with tents
Credit 3.1	Construction IAQ Management Plan—During Construction	some	Design, Construction	Medium, Large	protect ductwork, more applicable for large construction, MILCON, medical, etc.
Credit 3.2	Construction IAQ Management Plan—Before Occupancy	some	Design, Construction	Medium, Large	protect ductwork, more applicable for large construction, MILCON, medical, etc.
Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	some	Design, Construction, O&M	All	based solely on what is available.
Credit 4.2	Low-Emitting Materials—Paints and Coatings	some	Design, Construction, O&M	All	based solely on what is available.
Credit 4.3	Low-Emitting Materials—Flooring Systems	some	Design, Construction, O&M	All	based solely on what is available.
Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	some	Design, Construction, O&M	Medium, Large	based solely on what is available.
Credit 5	Indoor Chemical and Pollutant Source Control	some	Design, Construction, O&M	All	prefer to store items outdoors or in separate storage bldg
Credit 6.1	Controllability of Systems—Lighting	yes	Design, Construction, O&M	Medium, Large	individual controls and task lighting preferable. Lighting controls with occupancy & daylighting sensors better if available.

LEED 2009 for New Construction and Major Renovations		Applicability	Phase	Base Camp Size	Comments
Credit 6.2	Controllability of Systems—Thermal Comfort	some	Design, Construction, O&M	Medium, Large	more appropriate for habitation areas and large MILCON/medical facilities.
Credit 7.1	Thermal Comfort—Design	some	Design, Construction, O&M	Medium, Large	more appropriate for habitation areas and large MILCON/medical facilities.
Credit 7.2	Thermal Comfort—Verification	no			
Credit 8.1	Daylight and Views—Daylight	some	Design, Construction	Medium, Large	better to use daylight methods other than windows
Credit 8.2	Daylight and Views—Views	no			windows are a risk due to force protection issues
	Innovation and Design Process				
Credit 1.1	Innovation in Design: Specific Title	n/a			
Credit 1.2	Innovation in Design: Specific Title	n/a			
Credit 1.3	Innovation in Design: Specific Title	n/a			
Credit 1.4	Innovation in Design: Specific Title	n/a			
Credit 1.5	Innovation in Design: Specific Title	n/a			
Credit 2	LEED Accredited Professional	some			might get lucky
	Regional Priority Credits				
Credit 1.1	Regional Priority: Specific Credit				only available in the U.S.
Credit 1.2	Regional Priority: Specific Credit				only available in the U.S.
Credit 1.3	Regional Priority: Specific Credit				only available in the U.S.
Credit 1.4	Regional Priority: Specific Credit				only available in the U.S.

Appendix C: Highest-Priority Criteria

	Credit	Rating Tools	Topic	Comments
Water and Wastewater	Innovative Wastewater Technologies	LEED 2009 for NC & MR	Water Efficiency	Cascading water use, save potable water for essential uses.
	Wastewater Management	LEED 2009 for Neighborhood Development	Green Infrastructure and Buildings	Use systems that recycle/reuse graywater (showers, laundry, vehicle wash racks). Design for cascading water reuse: e.g., graywater for construction or dust abatement. Read credit for other examples.
	REDUCE POTABLE WATER CONSUMPTION	Envision 2.0	Resource Allocation	First - Cite CERL and other reports. Location affects availability and cost of generating potable water. Consider potable water reduction strategies for all uses and contracts. Cascading water use / reuse - use appropriate treatment stds for different uses (potable = drinking, cooking and bathing (?), brackish or grey water for dust suppression, appropriate water for concrete). Look at life cycle costs of water treatment systems - e.g., ROWPU is effective but has high O&M costs.
	PREVENT SURFACE AND GROUNDWATER CONTAMINATION	Envision 2.0	Natural World	Applies to the Base Camp, soldiers & contractors. Avoid surface and groundwater contamination. Refer to Army Standard Operating Procedures and policies apply for spill response, secondary containment, hazardous response, etc.
	Building Water Efficiency	LEED 2009 for Neighborhood Development	Green Infrastructure and Buildings	see LEED NC
Available Resources	Building Reuse—Maintain 50% of Interior Non-Structural Elements	LEED 2009 for NC & MR	Materials and Resources	Reuse building if meets mission requirements and if culturally significant preserve the character of the building
	Historic Resource Preservation and Adaptive Reuse	LEED 2009 for Neighborhood Development	Green Infrastructure and Buildings	Preserve, protect, respect historical and culturally significant structures, features. If used for military ops, preserve and restore before turnover.
	PRESERVE HISTORIC AND CULTURAL RESOURCES	Envision 2.0	Quality of Life	Want to avoid if possible, preserve and protect if required. May have to plan access for local people to certain sites.
	Protect and maintain unique cultural and historical places	The Sustainable Sites Initiative	Human Health and Well-Being	Conduct thorough EBS to identify cultural resources. Coordinate with local authorities.
	Maintain on-site structures, hardscape, and landscape amenities	The Sustainable Sites Initiative	Materials Selection	Maximize use of existing infrastructure, maintain as appropriate.
	USE RECYCLED MATERIALS	Envision 2.0	Resource Allocation	Maximize use of existing infrastructure and construction materials. Use recycled materials if possible.
	Recycled Content	LEED 2009 for NC & MR	Materials and Resources	do it, but the metrics are different.
	Recycled Content in infrastructure	LEED 2009 for Neighborhood Development	Green Infrastructure and Buildings	Maximize use of recycled materials. Reclaimed concrete for road gravel. Read credit.
	Regional Materials	LEED 2009 for NC & MR	Materials and Resources	promote the use of local materials and techniques to reduce transportation, increase local skilled labor pool, and create culturally & environmentally preferable facilities.
	USE REGIONAL MATERIALS	Envision 2.0	Resource Allocation	Use not only regional materials but also regional construction techniques.

	Use regional materials	The Sustainable Sites Initiative	Materials Selection	Use of local materials and construction techniques reduces transportation costs and increases pool of skilled labor.
	Materials reuse	LEED 2009 for NC & MR	Materials and Resources	do it, but the metrics are different.
	Reuse salvaged materials and plants	The Sustainable Sites Initiative	Materials Selection	Maximize use of on-site and salvaged materials.
Energy	Infrastructure Energy Efficiency	LEED 2009 for Neighborhood Development	Green Infrastructure and Buildings	Strive to make basic infrastructure more efficient. Consider elevated water tanks vs. pump driven pressure lines. Minimize electrical line runs to reduce losses. Stand alone PV powered security lighting. Cascading water reuse infrastructure.
	USE RENEWABLE ENERGY	Envision 2.0	Resource Allocation	Key to reducing fossil fuel use. If you reduce energy use enough you can supply power via renewable resources. For facilities plan space & set up smart grids & energy storage or components that can operate independently off renewable sources (like stand alone PV security lighting).
	On-Site Renewable Energy	LEED 2009 for NC & MR	Green Infrastructure and Buildings	Site layout and building orientation should facilitate the use of PV if implemented. Consider solar, wind, geothermal, small scale or micro hydro-electric, or biomass. May require basic smart grid infrastructure to incorporate these. Look at space requirements for solar farm or other technologies.
	On-Site Renewable Energy Sources	LEED 2009 for Neighborhood Development	Green Infrastructure and Buildings	Site layout and building orientation should facilitate the use of PV if implemented. Consider solar, wind, geothermal, small scale or micro hydro-electric, or biomass. May require basic smart grid infrastructure to incorporate these. Look at space requirements for solar farm or other technologies.
	Building Energy Efficiency	LEED 2009 for Neighborhood Development	Green Infrastructure and Buildings	see LEED NC
	REDUCE ENERGY CONSUMPTION	Envision 2.0	Resource Allocation	Start from the beginning and think hard about this. Very important to save energy, reduce costs and save lives. Cite CERL Operational Energy Report.
Waste	Storage and Collection of Recyclables	LEED 2009 for NC & MR	Materials and Resources	put collections of recylables near point of disposal
	Construction Waste Management	LEED 2009 for NC & MR	Materials and Resources	do it, but the metrics are different.
	Solid Waste Management	LEED 2009 for Neighborhood Development	Green Infrastructure and Buildings	Read credit. Include recycling and reuse stations. Collect paper, glass, cardboard & metals. (and useable wood). Don't let hazardous materials go into landfill. Compost station? Reuse materials as much as possible. (One stop waste disposal).
	DIVERT WASTE FROM LANDFILLS	Envision 2.0	Resource Allocation	This is a very important consideration. Look at one stop waste disposal - where you include all aspects of waste disposal in one area. Compost food waste, establish scrap wood pile, scrap metal pile, ammo amnesty spots, plastics & Styrofoam, etc. Segregate waste streams for maximum reuse and recycling.
	Design for deconstruction and disassembly	The Sustainable Sites Initiative	Materials Selection	Utilize standard size materials and assemble using bolt and screw connections that can be disassembled. See references page 126.
	Divert construction and demolition materials from disposal	The Sustainable Sites Initiative	Construction	Non-hazardous construction demolition materials should be reused for current or stockpiled for future projects. Repurpose if feasible. Minimize construction debris that must be disposed of in burn pit or landfill.

	Provide for storage and collection of recyclables	The Sustainable Sites Initiative	Operations and Maintenance	Provide recycling collection at point of use to make it easy to comply (i.e., plastic bottles outside of DFAC). Inspect waste loads to minimize recyclable disposal.
	PROVIDE FOR DECONSTRUCTION AND RECYCLING	Envision 2.0	Resource Allocation	Think about what happens after base camp occupants move out. Avoid problems such as foamed tents and buildings that can't be reused by local populations. Think about disassembling components for reuse. Good example - use exterior conduit so wiring can be converted to host nation code.
Master Planning	Compact Development	LEED 2009 for Neighborhood Development	Smart Location and Linkage	Plan carefully to accommodate similar functions in the same area to make development compact. Concept applies, same metrics won't.
	Access to Civic and Public Spaces	LEED 2009 for Neighborhood Development	Neighborhood Pattern and Design	Locate life support areas as close as possible to common use areas (PX, Post Office, Finance Office, Learning Center). Read criteria and apply if possible.
	Walkable Streets	LEED 2009 for Neighborhood Development	Neighborhood Pattern and Design	Want major roads to have sidewalks, and provide safe walking paths for base camp occupants. Won't apply the specific LEED-ND criteria. Pay special attention to roads that connect LSA (life support areas) to common use areas.
	Reduced Parking Footprint	LEED 2009 for Neighborhood Development	Neighborhood Pattern and Design	Metrics don't exactly apply. Concept of discouraging parking in LSA applies - consolidate parking in vehicle motor pools, and permit mission only parking at command and control facilities. Provide bicycle parking where appropriate.
	Use an integrated site development process	The Sustainable Sites Initiative	Pre-Design Assessment and Planning	Use multi-disciplianry team during master planning process.
	Access to Recreation Facilities	LEED 2009 for Neighborhood Development	Neighborhood Pattern and Design	locate life support areas as close as possible to common use areas (DFAC, gym, ballfields). Read criteria and apply if possible.
	IMPROVE SITE ACCESSIBILITY, SAFETY AND WAYFINDING	Envision 2.0	Quality of Life	Master planning key to enhancing access and safety. Need to consider soldier pedestrian paths to essential living and recreational and work facilities. Separate heavy truck traffic from life support areas. Protect secure, cultural and environmentally sensitive areas.
	Provide for optimum site accessibility, safety, and wayfinding	The Sustainable Sites Initiative	Human Health and Well-Being	Good master planning to provide easy, safe access to facilities within the camp.
	IMPROVE INFRASTRUCTURE INTEGRATION	Envision 2.0	Leadership	Apply good master planning principles to achieve higher performance.

Further Considerations	Promote sustainability awareness and education	The Sustainable Sites Initiative	Human Health and Well-Being	Make it easy for Soldiers to help meet with sustainable goals. Provide awareness campaigns and tie sustainability practices to force protection payoff.
	Plan for sustainable site maintenance	The Sustainable Sites Initiative	Operations and Maintenance	Some concepts apply - see specific credits for details. See format for potential use.
	PLAN FOR LONG-TERM MONITORING AND MAINTENANCE	Envision 2.0	Leadership	Build maintenance into LOGCAP contracts and other O&M processes. Consider appropriate O&M for the lifespan of the component (and base camp). Consider implementing metering and monitoring of facilities to diagnose facility performance and reduce energy/water consumption.
	IMPROVE COMMUNITY MOBILITY AND ACCESS	Envision 2.0	Quality of Life	Site selection, avoiding traditional community routes or access roads. Set up entry control points and truck holding area to minimize traffic congestion.
	PROVIDE FOR STAKEHOLDER INVOLVEMENT	Envision 2.0	Leadership	Think of community as people inside the base camp fence. For that community, use the base camp planning board process and the Joint Facilities Use Board (JFUB). If the project has the potential to impact the host nation community, then you should engage the local nation leadership.

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14. ABSTRACT

Contingency base supply lines represent an ongoing vulnerability in U.S. contingency operations. Base camp materiel, energy, and water requirements must be met using risky ground convoys or, alternately, expensive air transport. The problem is aggravated by a lack of base camp planning and design guidelines, which negatively affect operational efficiency and logistical sustainability. U.S. design and construction communities have developed criteria to improve the sustainability of standard facilities and infrastructure, such as Leadership in Energy and Environmental Design (LEED) and the Sustainable Sites Initiative. The direct applicability of such criteria to military contingency operations is limited, however, because of unique military requirements and the scarcity of U.S. standard construction materials and equipment.

This study examined various design and construction sustainability pro-grams and identified concepts, guidelines, and practices relevant to military contingency infrastructure construction. The report collects and adapts design and construction criteria that can feasibly be applied by engineers, planners, and base operators to establish and sustain contingency bases. Application of these guidelines could significantly decrease the logistical footprint of the contingency base by reducing the consumption of construction materials, energy, and water.

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